LEVEL II ①

MIAMI INTERNATIONAL AIRPORT
TECHNICAL PLAN

AIRPORT IMPROVEMENT
TASK FORCE DELAY STUDIES

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Prepared by
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16. Abstract

This report contains supporting documentation for the detailed analysis of the Miami International Airport. The analysis was conducted by the Airport Improvement Working Group which has representatives from the airport sponsor, the Air Transport Association, the airlines serving Miami, and the Federal Aviation Administration. Technical support was provided by Peak, Marwick, Mitchell & Co., and the FAA Technical Center. The purpose of the analysis was to determine the causes of delay and the potential delay reduction benefits of recommended improvements. The effort was part of the Airport Improvement Program.

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MIAMI INTERNATIONAL AIRPORT TECHNICAL PLAN

Airport Improvement Task Force Delay Studies

Volume II.

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Atlantic City, New Jersey

and

Peat, Marwick, Mitchell & Co.
San Francisco, California

II) October 1978

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I. INTRODUCTION

This technical plan has been designed for use by FAA Headquarters, the Miami Task Force, NAFEC, and PMM & Co. during the Miami International Airport Delay Improvement Study. The plan consists of three parts and includes recommendations for the following:

- <u>Approach and Milestones</u>--establishes work tasks, responsibilities, and the interrelationship of Task Force participants, as well as major milestones representing decision/approval/redirection points in the study. (Chapter II)

- <u>Experimental Design</u>--describes criteria and recommendations for model runs to prepare delay estimates. (Chapter III)

- <u>Data Requirements</u>--specifies model inputs and outputs, and data collection needs and responsibilities. (Chapter IV)

Task Force Objectives

FAA Headquarters established the following objectives to guide the delay analysis:

- Identify causes of delay associated with terminal airspace, airfield, and apron/gate area operations.

- Determine delay reduction benefits of alternative air traffic control (ATC) procedures, Facilities and Equipment (F&E), Airport Development Aid Program (ADAP), and Research, Engineering and Development (R, E&D) improvement options for immediate, near-term (pre-1985) and long-term (post-1985) implementation.

- Establish the relationships between air traffic demands and delay in the present and in the future.

This technical plan describes a recommended approach for the Miami Task Force delay studies in response to these objectives and to the specific needs of the Miami Task Force. The delay studies are oriented to assist the Task Force in evaluating high-priority airfield improvements

that can be implemented in the near future, and to assist FAA Head-
quarters in evaluating the potential benefits of its research and
development activities.

Approach and Milestones

Chapter II of this technical plan identifies specific milestones and task
responsibilities for FAA Headquarters, the Miami Task Force, NAFEC,
and PMM&Co.

Six major tasks are identified:

- Develop Technical Plan and Experimental Design

- Collect Input Data

- Perform Model Calibration

- Run Delay Models

- Interpret Delay Results

- Develop Airport Delay Analysis Report

In addition, coordination meetings at key decision points and for purposes
of monitoring Task Force progress are discussed in Chapter II together
with recommendations for meeting objectives, agendas, and preparation
responsibilities.

Experimental Design

Chapter III of this technical plan describes the process of developing and
selecting experiments to be used for estimating delays. This process is
referred to as "experimental design."

Because of the large number of possible near-term and long-term improve-
ments, as well as the variety of operating conditions to be considered
(runway use, weather, demand level, ATC system scenarios, etc.), a
screening process was used to select the delay experiments that are
recommended to meet the stated objectives.

As noted in Chapter III, experiments are planned to be conducted in two
stages so that final decisions on experiments scheduled for the second
stage can be reviewed after the results of the first-stage experiments are
evaluated.

<u>Data Requirements</u>

A series of models are available to assist the Task Force in computing delays to aircraft. These models are outlined in Appendix A.

The PMM&Co. airfield simulation model is available for computations of hourly and/or daily delays to aircraft. The simulation model also computes aircraft flow rates and travel times.

The annual delay model is available for computations of annual delays to aircraft. The annual delay model also computes distributions of average aircraft delays.

A number of additional models are also available to the Task Force, including (1) a weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center, and (2) an analytical runway capacity model that computes estimates of hourly runway capacity.

Data needs for model calibration and model runs to prepare delay estimates are discussed in Chapter IV. Some data are available from the Miami Interim Report*, some data will be derived from an analysis of historical data, and other data will be collected by field observations.

A preliminary airfield network reflecting the current configurations for Miami International Airport was prepared from available data and is set forth in Figure I-1.

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*Miami International Airport Improvement Program, Interim Report, October 1977.
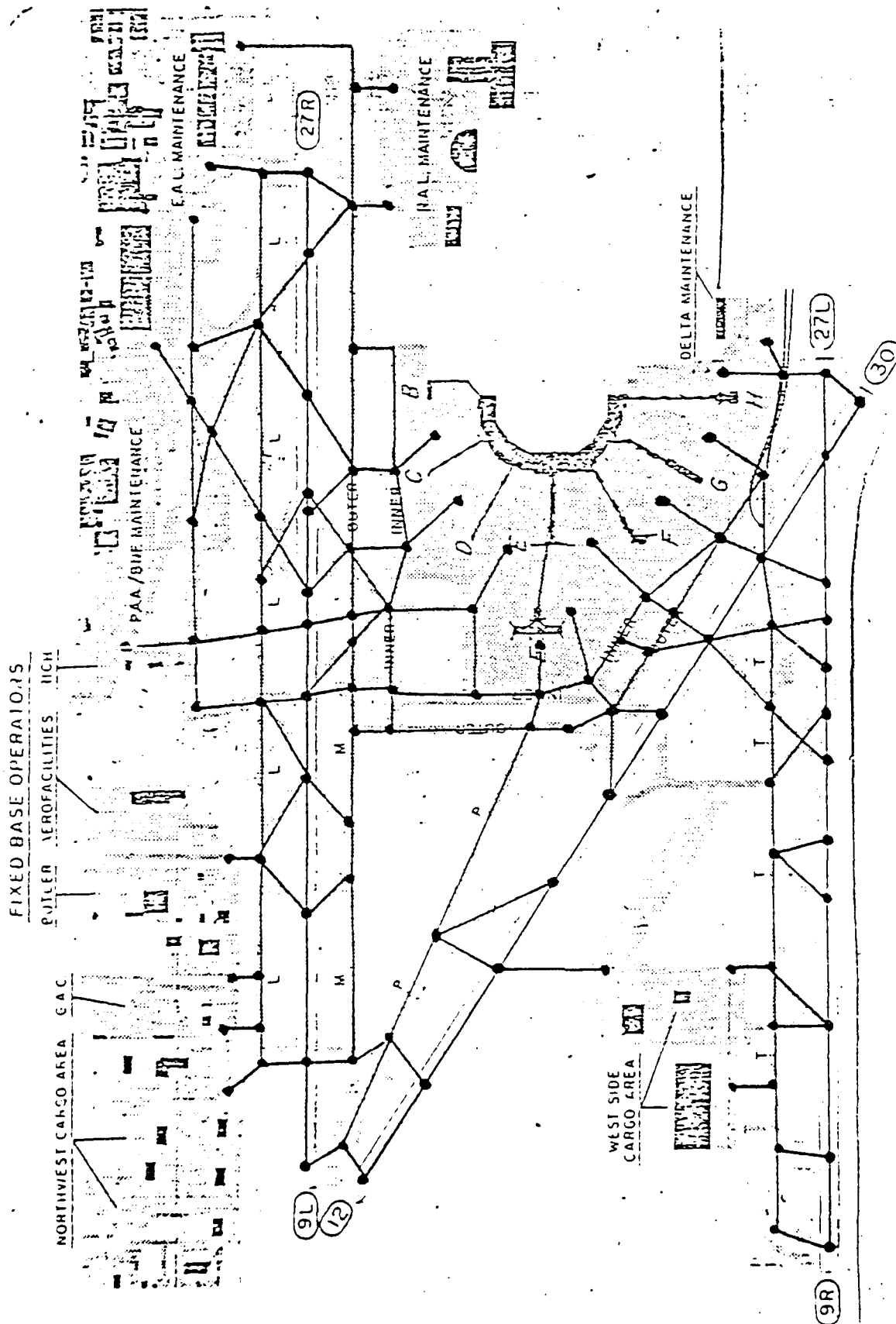
Figure 1-1
PRELIMINARY AIRFIELD NETWORK
Miami International Airport
Delay Improvement Study
October 1978

II. APPROACH AND MILESTONES

Organization

The organizational framework for the Miami Task Force activity is shown in Figure II-1.

The FAA Southern Region manages the activities of the Miami Task Force. Executive direction for the activities is provided by the FAA Air Traffic and Airways Facilities Program Management Staff (ATF-4).

The FAA Office of Systems Engineering Management (AEM-100) manages the technical support for the Task Force analysis, including resources from NAFEC, PMM&Co., and other support.

Work Tasks and Responsibilities

Six major tasks are to be performed by the Miami Task Force, FAA Headquarters, NAFEC, and PMM&Co.:

1. Develop Technical Plan and Experimental Design

2. Collect Input Data

3. Perform Model Calibration

4. Run Delay Models

5. Interpret Delay Results

6. Develop Task Force Delay Analysis Report

Task interrelationships are given in Figure II-2. Descriptions of the six major tasks are given below.

Task 1--Develop Technical Plan and Experimental Design. NAFEC prepares a suggested technical plan for the airport. The technical plan describes the recommended method of approach for the conduct of the delay studies at the airport, including a recommended airport-specific experimental design, task responsibilities, and time schedules.

Office of Systems
Engineering Management
(AEM-100)

Program Management Staff
Air Traffic and Airways
Facilities
(ATF-4)

PMM&Co.

NAFEC
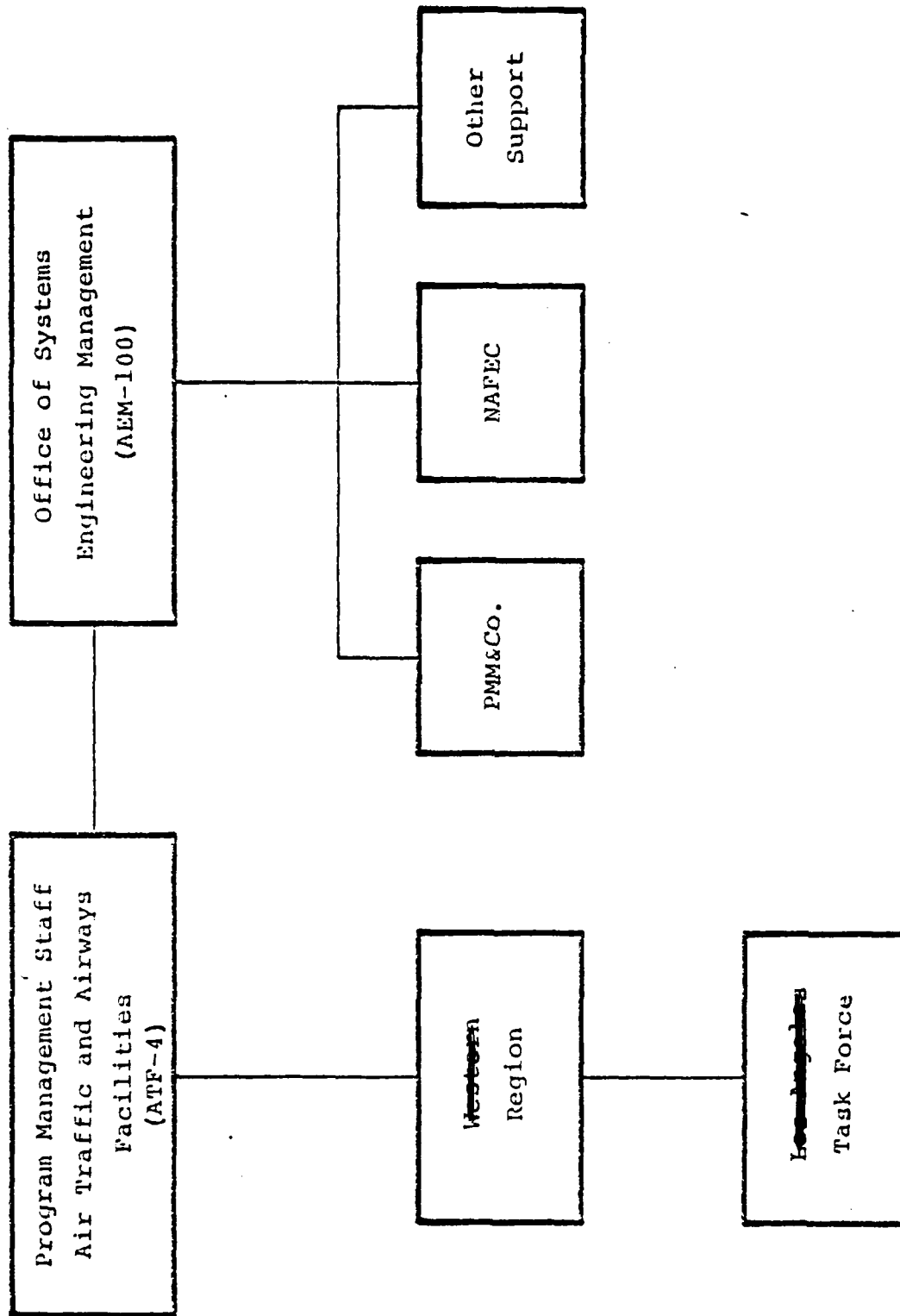
Other
Support

Region

Task Force

Figure II-1

ORGANIZATIONAL FRAMEWORK
Miami International Airport
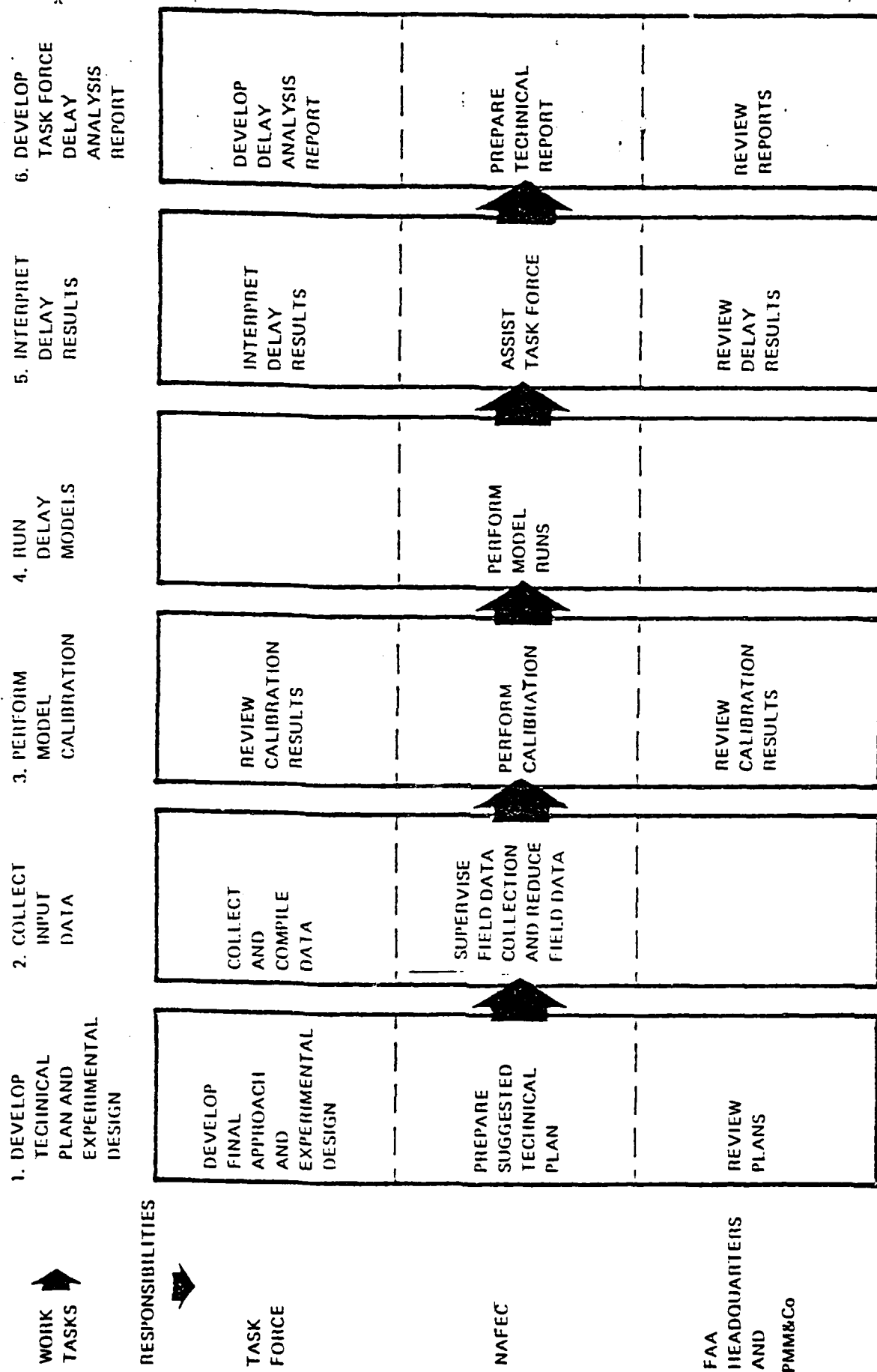Delay Improvement Study
October 1978

Figure II-2

AIRPORT TASK SEQUENCE
Miami International Airport
Delay Improvement Study
October 1978

II-3

The plan also identifies methods for obtaining delay estimates using the PMM&Co. airfield simulation model, annual delay model, or other techniques as appropriate. The Task Force and FAA Headquarters review the plan and the Task Force develops a final technical approach and experimental design.

Task 2--Collect Input Data. NAFEC describes data requirements for applying the delay model(s) for developing delay estimates. The Task Force (with assistance from NAFEC and PMM&Co.) establishes data needs for delay experiments, and collects, compiles, and reviews the data. The data to be collected include field data, data currently in the possession of Task Force members, and data to be provided by NAFEC and PMM&Co. The field data are reduced by NAFEC using currently available data reduction computer programs.

Task 3--Perform Model Calibration. On the basis of data obtained in Task 2, NAFEC consolidates the data, performs calibration model runs, and demonstrates results to the Task Force. The model calibration assures that the simulation model correctly reflects the site-specific airport situation.

Task 4--Run Delay Models. NAFEC performs model runs for delay estimates. Models used may include the airfield simulation model, as well as ancillary models such as the annual delay model. The model runs result in the production of delay estimates for the experiments established in the experimental design.

Task 5--Interpret Delay Results. The Task Force (with assistance from NAFEC and PMM&Co.) interprets the delay estimates. Interpretation of the total set of delay estimates provides guidance in evaluating the impact on delay (for the appropriate study cases) of one or more of the following: (1) changes in demand level, including aircraft mix; (2) changes in runway use patterns; (3) changes to runway/taxiway/ apron areas; (4) new ATC procedures, including changes in separation standards; and (5) navigation aids and other ATC improvements.

Task 6--Develop Task Force Delay Analysis Report. NAFEC prepares a technical report that documents the delay analyses performed. The Task Force, FAA Headquarters, and PMM&Co. review the technical report. The Task Force develops a Delay Analysis Report

that includes (1) the conclusions drawn by the Task Force from the delay analyses and (2) a set of recommendations for reducing delays to aircraft at the airport.

Milestones and Schedule

A series of overall milestones are recommended concerning the completion of significant tasks, delivery of products, and decision points of Miami Task Force activities, as listed in Table II-1.

Task Force Meetings. At key decision points and for purposes of monitoring progress in relation to the study milestone, a series of Task Force meetings are recommended.

The specific objectives and outputs of the meetings are summarized in Table II-2. Suggested details on the objectives, agendas, and preparation responsibilities for these meetings are shown in the following list.

Task Force Meeting No. 1:

a. Objectives

Briefings will be given to bring Task Force members up to date on plans, schedules, and responsibilities. The technical plan and experimental design will be reviewed, and a plan will be established to collect and compile the required model input data to obtain delay estimates.

b. Agenda

1. Introduction and background

2. Presentation on technical plan

3. Presentation and discussion of data requirements for model calibration and delay experiments

4. Establishment of data collection and reduction procedure (including commitment of personnel and data responsibilities)

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TABLE II-1

TASK FORCE AIRPORT MILESTONES

Miami International Airport Delay Improvement Study

Milestone No.	Milestone	Target Completion Date
1	Review technical plan	October 12, 1978
2	Identify data requirements	October 12, 1978
3	Collect field data	November 3, 1978
4	Consolidate calibration data	November 30, 1978
5	Complete model calibration	December 15, 1978
6	Consolidate delay input data	December 15, 1978
7	Complete delay runs	February 28, 1979
8	Interpret impact of delay results	March 14, 1979
9	Review draft reports	April 12, 1979
10	Prepare reports	April 30, 1979

TABLE II-2

RECOMMENDED TASK FORCE MEETINGS

Miami International Airport Delay Improvement Study

Meeting No.	Objectives	Outputs	Target Meeting Date
1	Give briefing on technical plan, experimental design, and data requirements	Comments on technical plan and data requirements for calibration and delay study	October 12, 1978
2	Review calibration and finalize experimental design	Calibration data and experimental design	November 30, 1978
3	Review calibration results and delay input data	Approved model and input data for delay studies	January 17, 1979
4	Review Stage 1 delay runs and plan for Stage 2 delay runs	Updated Stage 2 delay input data	February 14, 1978
5	Review and interpret impacts of delay results	Impacts of delay results	March 14, 1979
6	Review draft NAFEC technical report and Task Force delay analysis report	Comments on draft report	April 12, 1979

5. Establishment of experimental design subgroup

6. Working session on experimental design

7. Definition of procedure to develop demand forecasts

8. Description of tasks to be performed prior to Task Force Meeting No. 2

9. Preparations for Task Force Meeting No. 2

c. Preparation Responsibilities

NAFEC will develop briefing materials on the technical plan, experimental design, data requirements, and field data collection and Task Force members will read and review the technical plan. The Task Force Chairman will work with FAA Headquarters to determine resource needs and commitments.

Task Force Meeting No. 2:

a. Objectives

The Task Force will review the data for model calibration, review progress on development of model input data for delay estimates, and finalize the experimental design.

b. Agenda

1. Review of minutes of Task Force Meeting No. 1

2. Presentation on model calibration data collection and reduction

3. Working session on calibration data

4. Selection of input and output data for model calibration run

5. Review of progress on data development for delay estimates

6. Review of experimental design

7. Finalization of demand forecast data

8. Description of tasks to be performed prior to
Task Force Meeting No. 3

9. Arrangements for Task Force Meeting No. 3

c. Preparation Responsibilities

NAFEC, and the Task Force will develop briefing materials
describing model input data collected and reduced. The
experimental design subgroup will develop a recommended
experimental design for review and discussion.

Task Force Meeting No. 3:

a. Objectives

The Task Force will review the model calibration results
and establish the input data for delay estimates.

b. Agenda

1. Review of minutes of Task Force Meeting No. 2

2. Presentation and discussion of model calibration results

3. Presentation and discussion of input data for delay
estimates

4. Select input data for delay estimates

5. Description of tasks to be performed prior to Task Force
Meeting No. 4

6. Arrangements for Task Force Meeting No. 4

c. Preparation Responsibilities

NAFEC will prepare briefing materials describing model
calibration results and input data developed for delay

estimates. The Task Force will prepare briefing materials describing input data developed for delay estimates.

Task Force Meeting No. 4:

a. Objectives

The Task Force will review results of Stage 1 delay estimates and update requirements for Stage 2 delay estimates.

b. Agenda

    1. Review of minutes of Task Force Meeting No. 3

    2. Interpretation and discussion of Stage 1 delay estimates

    3. Definition of requirements for Stage 2 delay estimates

    4. Description of tasks to be performed prior to Task Force Meeting No. 5

    5. Arrangements for Task Force Meeting No. 5

c. Preparation Responsibilities

NAFEC will develop briefing materials on the results of Stage 1 delay estimates and input data for Stage 2 delay estimates.

Task Force Meeting No. 5:

a. Objectives

The Task Force will review the results of Stage 2 delay estimates and interpret the impacts of the results. The Task Force will also review the schedules and outlines of the Task Force delay analysis report and NAFEC technical report.

b. Agenda

    1. Review of minutes of Task Force Meeting No. 4

    2. Presentation of Stage 2 delay estimates

    3. Interpretation of impact of delay results

    4. Review of Task Force and NAFEC report outlines and completion schedules

    5. Description of tasks to be performed prior to Task Force Meeting No. 6

    6. Arrangements for Task Force Meeting No. 6

c. Preparation Responsibilities

NAFEC will develop briefing materials on results of Stage 2 delay estimates and on the target schedule and outline for the NAFEC technical report. The Task Force will develop briefing materials on the schedule and preliminary outline of the Task Force delay analysis report.

Task Force Meeting No. 6:

a. Objectives

The draft technical report prepared by NAFEC and the delay analysis report prepared by the Task Force will be reviewed. Plans to work toward implementation of improvements will be discussed.

b. Agenda

    1. Review of minutes of Task Force Meeting No. 5

    2. Presentation and discussion of draft NAFEC technical report

    3. Presentation and discussion of draft Task Force delay analysis report

4. Description of remaining reporting and implementation
    activities

5. Concluding remarks by FAA Headquarters, including
    discussion of Task Force recommendations

c. Preparation Responsibilities

The Task Force and NAFEC will develop briefing materials
on the draft reports. The Task Force will review the
draft NAFEC technical report and draft Task Force delay
analysis report.

Schedule. A suggested schedule for performance of the various
tasks is illustrated in Table II-3. The schedule is keyed to the mile-
stones and Task Force meetings described previously, as well as
the time requirements and interactions of the various tasks shown in
Figure II-2. The suggested schedule also reflects the planning for
other Task Force airports to conserve resources and overall schedules.

TABLE II-3

MIAMI INTERNATIONAL AIRPORT DELAY IMPROVEMENT STUDY

SUGGESTED TASK FORCE ACTIVITY SCHEDULE

Task or Major Subtask	Target Start Date	Target Completion Date
1. Develop recommended Technical Plan and Experimental Design	September 6, 1978	October 6, 1978
2. Collect input data	September 6, 1978	September 14, 1978
Establish input data requirements	October 30, 1978	November 3, 1978
Collect field data	October 12, 1978	November 10, 1978
Collect Task Force data	October 12, 1978	November 10, 1978
Collect FAA ATC system scenario data	October 12, 1978	November 10, 1978
Consolidate input data for delay estimates	November 10, 1978	December 23, 1978
Review input data	December 16, 1978	January 17, 1979
Update Stage 2 data	November 16, 1978	November 24, 1978
3. Perform model calibration		
Consolidate calibration data	November 13, 1978	November 30, 1978
Perform calibration model run	November 30, 1978	November 16, 1978
Review calibration results	December 16, 1978	January 17, 1979
4. Run delay models		
Perform Stage 1 runs	January 17, 1979	February 7, 1979
Review Stage 1 runs	February 7, 1979	February 14, 1979
Perform Stage 2 runs	February 20, 1979	February 28, 1979
5. Interpret delay results		
Interpret Stage 1 results	February 7, 1979	February 14, 1979
Interpret Stage 2 results	March 1, 1979	March 8, 1979
Review delay results	March 1, 1979	March 14, 1979
6. Develop NAFEC technical report and Task Force delay analysis report		
Prepare draft reports	March 14, 1979	March 28, 1979
Review draft reports	March 28, 1979	April 12, 1979
Prepare final reports	April 12, 1979	April 30, 1979

III.   EXPERIMENTAL DESIGN

The process of selecting and developing delay experiments to be used
for estimating delay values is referred to as "experimental design."
Because there are many combinations of possible near- and long-term
improvements as well as a variety of operating conditions to be
considered (runway use, weather, demand level, ATC scenarios, etc.),
one important activity was the selection of the combinations of improve-
ments and operating conditions for recommended experiments.

The process of screening and evaluation of possible experiments used in
preparing the technical plan reflects the following:

- Objectives of the Miami Task Force and FAA Headquarters

- Results of the capacity phase of the Miami Task Force Study
  documented in the Interim Report

- Improvements and changing conditions since the Miami Interim
  Report

- Impact of near- and long-term improvements on delay
  reduction (reflecting the frequency of impact, as well as
  the magnitude and importance of the impact during critical
  periods at the airports, e.g., high delays in low visibility
  conditions)

- ATC system scenarios considered likely in the future

To achieve Task Force objectives, two types of delay estimates are
required: (1) hourly and/or daily delays, which may be produced by
the airfield simulation model, and (2) annual delays, which may be
produced by annual delay model.

Descriptions of the airfield simulation model, annual delay model,
and other ancillary models available to the Task Force are presented
in Appendix A.

Hourly and/or daily delay estimates will be used:

- To assess details of aircraft operations on the existing airfield

- To estimate the impact of near-term (pre-1985) improvements

Annual delay estimates will be used:

- To estimate the impact of long-term (post-1985) improvements

- To facilitate economic analysis in both the near term and the long term

To achieve these objectives, a set of experiments is recommended for three time frames: today, pre-1985, and post-1985. The experiments will estimate aircraft delays that may occur in these three time frames.

Delay experiments are recommended that will illustrate the delays to aircraft that may occur in the future under alternative assumptions or "scenarios."

The first scenario is the situation "most likely" to occur in a particular time frame--for example, the pre-1985 most likely scenario.

To estimate aircraft delays for this scenario, it is necessary to establish (1) the most likely level of demand, (2) the package of near-term improvements that is most likely to be implemented, and (3) the most likely ATC system scenario. Development of this scenario requires judgments by the Task Force on the most likely situation in the pre-1985 time frame.

The impact of individual improvement items can then be assessed by performing additional experiments and comparing the resulting delays with the delays estimated for the most likely scenario.

For example, assume that an additional taxiway is planned for implementation in the post-1985 time frame. Then the most likely pre-1985 scenario will exclude this additional taxiway. The impact of the additional taxiway on delays in the pre-1985 time frame can be estimated by comparing two delay estimates: (1) delays computed for the pre-1985 most likely scenario (without the additional taxiway), and (2) delays

computed by an additional experiment that adds the additional taxiway
to the package of most likely pre-1985 near-term improvements.

Therefore, delay experiments are recommended that establish most
likely delays to aircraft and estimate delay savings associated with
individual improvement items.

Thirty-three experiments are recommended for Miami International
Airport, as listed in Table III-1.

The experiments are divided into two stages. This permits the results
of the first-stage experiments to influence and possibly redirect the
second-stage experiments.

Table III-1 shows that 24 delay experiments are planned to be performed
with the airfield simulation model (ASM), and 9 experiments are planned
to be performed with the annual delay model (ADM).

For each delay experiment, Table III-1 also shows the study case,
arrival and departure runways, weather, and the time frame for the
demand, ATC system scenario, and near-term improvements.

Simulation Model Experiments

Twenty-four simulation model experiments are recommended to
compute hourly and/or daily delays to aircraft.

To establish the appropriate delay experiments, the capacity analyses
documented in the Miami Interim Report were examined, and discussions
were held with Task Force members. The interim report identified
study cases (combinations of runway use and weather). Four of the six
study cases and values of baseline hourly runway capacity considered
in the Miami Interim Report are depicted in Figure III-1, together
with 5 additional study cases suggested for inclusion in the delay study.

Six baseline experiments (Experiments 1 through 6) are recommended
to assess delays to aircraft in 1978 for different runway uses and
weather conditions.

Five additional experiments (Experiments 7, 8, 9, 10, and 17) are
included to show the consequences of not making any airfield or ATC

TABLE III-1

MIAMI DELAY EXPERIMENTS

| Experiment Number	Model	Study Case[a]	Arrival Runways	Departure Runways	Weather	Demand	ATC System Scenario[b]	Near-term Improvements[c]
Stage 1 Experiments								
1	ASM[d]	1	9L, 9R, 12	9L, 9R, 12	VFR1	Todays	Todays	None
2	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Todays	Todays	None
3	ASM	3	27L, 27R	27L, 27R, 30	VFR2	Todays	Todays	None
4	ASM	4	9L, 9R	9L, 9R, 12	IFR1	Todays	Todays	None
5	ASM	5	27L, 27R	27L, 27R	IFR1	Todays	Todays	None
6	ASM	8	9L	9L	IFR2	Todays	Todays	None
7	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Todays	None
8	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Pre-1985	Todays	None
9	ASM	4	9L, 9R	9L, 9R, 12	IFR1	Pre-1985	Todays	None
10	ASM	8	9L	9L	IFR2	Pre-1985	Todays	None
11	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985[e]
12	ASM	7	27L, 27R, 30	27L, 27R, 30	VFR2	Pre-1985	Pre-1985	Pre-1985[e]
13	ASM	9	9L, 9R	9L, 9R, 12	IFR2	Pre-1985	Pre-1985	1, 2[f]
14	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985, 50% less GA.[g]
15	ASM	5	27L, 27R	27L, 27R	IFR1	Pre-1985	Pre-1985	Pre-1985,
20	ASM	5	27L, 27R	27L, 27R	IFR1	Pre-1985	Pre-1985	Pre-1985, 50% less G. A.
Stage 2 Experiments								
17	ASM	3	27L, 27R	27L, 27R, 30	VFR2	Pre-1985	Todays	None
18	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Pre-1985	Pre-1985	Pre-1985
19	ASM	3	27L, 27R	27L, 27R, 30	VFR2	Pre-1985	Pre-1985	Pre-1985
21	ASM	9	9L, 9R	9L, 9R, 12	IFR2	Pre-1985	Pre-1985	Pre-1985, 25% less G. A.
22	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	Pre-1985, 75% less G. A.
23	ASM	1	9L, 9R, 12	9L, 9R, 12	VFR1	Pre-1985	Pre-1985	6[i]
24	ASM	5	27L, 27R	27L, 27R	IFR1	Todays	Todays	Pre-1985 + overflow parking[j]
25	ASM	2	27L, 27R, 30	27L, 27R, 30	VFR1	Pre-1985	Todays	Todays
16	ADM[h]	n.a.	n.a.	n.a.	n.a.	Todays	Pre-1985	Pre-1985
26	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Pre-1985	None
27	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Todays	Pre-1985
28	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Todays	None
29	ADM	n.a.	n.a.	n.a.	n.a.	Pre-1985	Post-1985	Post-1985
30	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Post-1985	Post-1985
31	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Post-1985	Post-1985
32	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Todays	None
33	ADM	n.a.	n.a.	n.a.	n.a.	Post-1985	Todays	None

See footnotes on following page

n.a. = not applicable

a. Study cases (combination of runway use and weather conditions) are defined in Figure III-1.
b. FAA will describe impact of pre-1985 and post-1985 ATC systems on model inputs.
c. Potential near-term improvements are identified in the Miami International Airport Improvement Task Force Interim Report, and in Appendix B.
d. Airfield Simulation Model
e. Task Force will establish packages of near-term improvements most likely to be implemented in the pre-1985 and post-1985 time frames. Improvements to runways 9L/27R, 9R/27L, and 12/30 identified as improvements 1, 2, and 3 in Appendix B most likely to be included in pre-1985 improvements.
f. Improvement #1 is an improved taxiway system of runway 9L/27R, centerline lighting and touch down zone lighting on runway 9L, and 250-foot baseline RVR systems on runway 9L/27R.
   Improvement #2 is centerline lighting and dual 250-foot baseline RVR systems on runway 9R/27L.
g. Reduction in general aviation achieved by upgrading Opa Locka and Tamiami General Aviation Reliever Airports.
h. Annual Delay Model
i. Improvement #6 is the use of 2 mile in-trail staggered parallel approaches.
j. Improvement #8 is overflow parking positions within the terminal area.

12/8/78
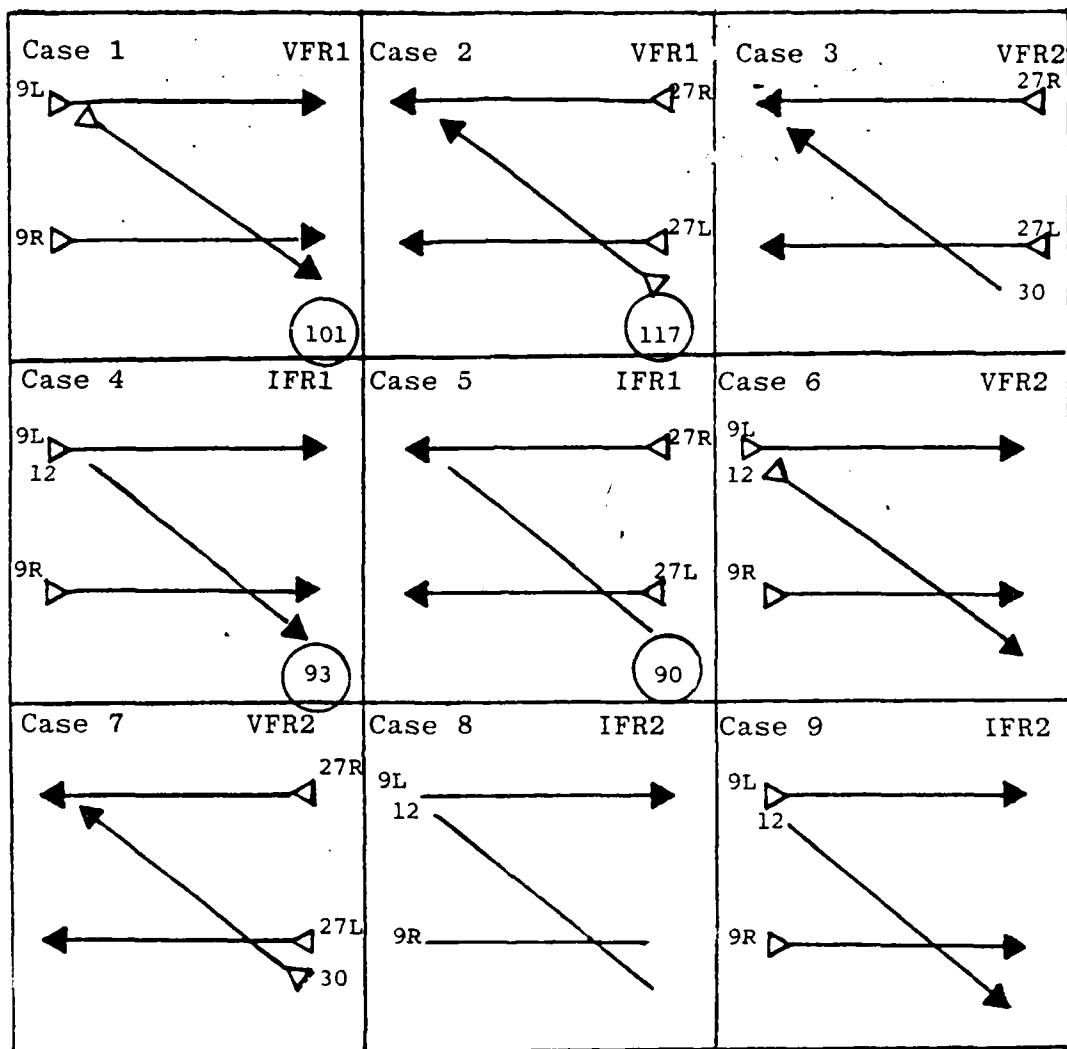
◁ Arrival Aircraft

◀ Departure Aircraft

Weather VFR1--Ceiling greater than 1500 feet and visibility greater than 5 miles

VFR2--Ceiling between 1000 feet and 1500 feet and visibility between 3 miles and 5 miles

IFR1--Ceiling between 200 feet and 1000 feet and/or visibility between 2400 feet RVR and 3 miles

IFR2--Ceiling between 200 feet and 1000 feet and/or visibility between 1800 feet RVR and 2300 feet RVR

FIGURE III-1

improvements in the near term while airport demand increases from today's level of activity to that forecast for the pre-1985 time frame.

Six experiments (Experiments 11, 12, 18, 19, 20, and 21) are recommended to assess delays to aircraft in the pre-1985 time frame if an improved ATC system scenario is available and if various physical improvements are implemented. These runs study the most likely situation with the most likely airfield and ATC near-term improvements.

To develop other experiments to estimate the impact of near-term improvements, the near-term improvement items identified in the Miami Interim Report (and listed in Appendix B) were assessed. This assessment resulted in recommendations to perform simulation model experiments associated with the following improvement items:

#1 Improve the taxiway system of runway 9L/27R. Install runway centerline lighting and touch down zone lighting on runway 9L. Install dual 250-foot baseline RVR systems on runway 9L/27R.

#2 Install runway centerline lighting and dual 250-foot baseline RVR systems on runway 9R/27L.

#3 Install high intensity runway lights, an Instrument Landing System, and an Approach Lighting System on runway 30. Provide paved blast protection shoulders on runway 12/30. Implement operational procedures to make greater use of the intersection take-off position on runway 30 and simultaneous use of runway 12 and 9R.

#4 Upgrade Opa Locka and Tamiami General Aviation Reliever Airports, to encourage low performance general aviation aircraft to relocate out of MIA.

#5 Study the feasibility of installing a VOR-DME on or in close vicinity to MIA.

#6 Use 2 mile in-trail staggered parallel approaches at MIA, to improve capacity without the extra tower staff required for full independent parallel approaches.

#7 Install Vortex Advisory System (VAS) monitors at both ends of all three runways at MIA.

#8   Provide overflow aircraft parking positions within the
     terminal area.

Experiment 13 is recommended to assess the delay impact of the runway
lighting improvements listed in improvements #1 and #2. The improved
taxiway system identified in #1 is tested in experiments 11 and 18 for
both eastwardly and westwardly flow of traffic under VFR1 weather
conditions.

Improvements to runway 12/30 (listed as improvement #3) can be
assessed by evaluating the results of experiments 12, 17, 20, and 21.

Four experiments are recommended to study improvement #4, the
upgrading of General Aviation Reliever Airports. Experiments 14, 15,
22, and 23 study the effects of this improvement by reducing the amount
of general aviation using Miami International Airport.

Experiment 24 is recommended to study improvement #6, the use of
2 mile in-trail staggered parallel approaches at MIA. Improvement
#8, the installation of overflow parking positions is recommended to
be studied using experiment 25.

The benefits of installing Vortex Advisory Systems (VAS) monitors at
both ends of all three runways is tested by being included in the most
likely pre-1985 ATC scenario. Experiments 11, 12, 18, 19, 20, and
21 are included to test the most likely pre-1985 airport and ATC
improvements.

Therefore, a total of 24 simulation model experiments are recommended:

   •   6 1978 baseline experiments

   •   5 experiments to show the impact of not making improvements
       while demand increases to the pre-1985 forecast level

   •   6 pre-1985 experiments for most likely scenarios of ATC
       and airport improvements

   •   7 experiments to assess near-term improvements identified
       in the Interim Report

Annual Delay Model Experiments

Nine annual delay model experiments are recommended to compute
annual delays to aircraft.

One baseline delay experiment is recommended to estimate annual
average delay to aircraft for today's situation (Experiment 16).

Two additional experiments are recommended to cover the most likely
scenario for two future time frames--pre-1985 (Experiment 26) and post-
1985 (Experiment 30).

Six additional sensitivity experiments are recommended to assess the
delays that may occur if the most likely scenario of combinations of
near-term improvements and ATC systems is not implemented, three
experiments in each of the pre-1985 and post-1985 time frames.   The
three pre-1985 experiments are designed to assess:

   .   the absence of airfield improvements
         (Experiment 27)

   .   the absence of future ATC systems
         (Experiment 28), and

   .   the do-nothing situation
         (Experiment 29)

The three post-1985 experiments (Experiments 31, 32, and 33) are
designed to perform the same assessments in the longer time frame.

The interrelationship of these nine annual delay model experiments is
illustrated in Figure III-2, which shows the variation of average annual
aircraft delay with time.   The variation is based on hypothetical results
of the nine annual delay estimates.

The foregoing paragraphs describe 33 recommended delay experiments.
Additional or alternative delay experiments may be considered by the
Task Force. It is suggested that an experimental design subgroup meet
to discuss the recommended experiments and to finalize those experiments
to be performed.
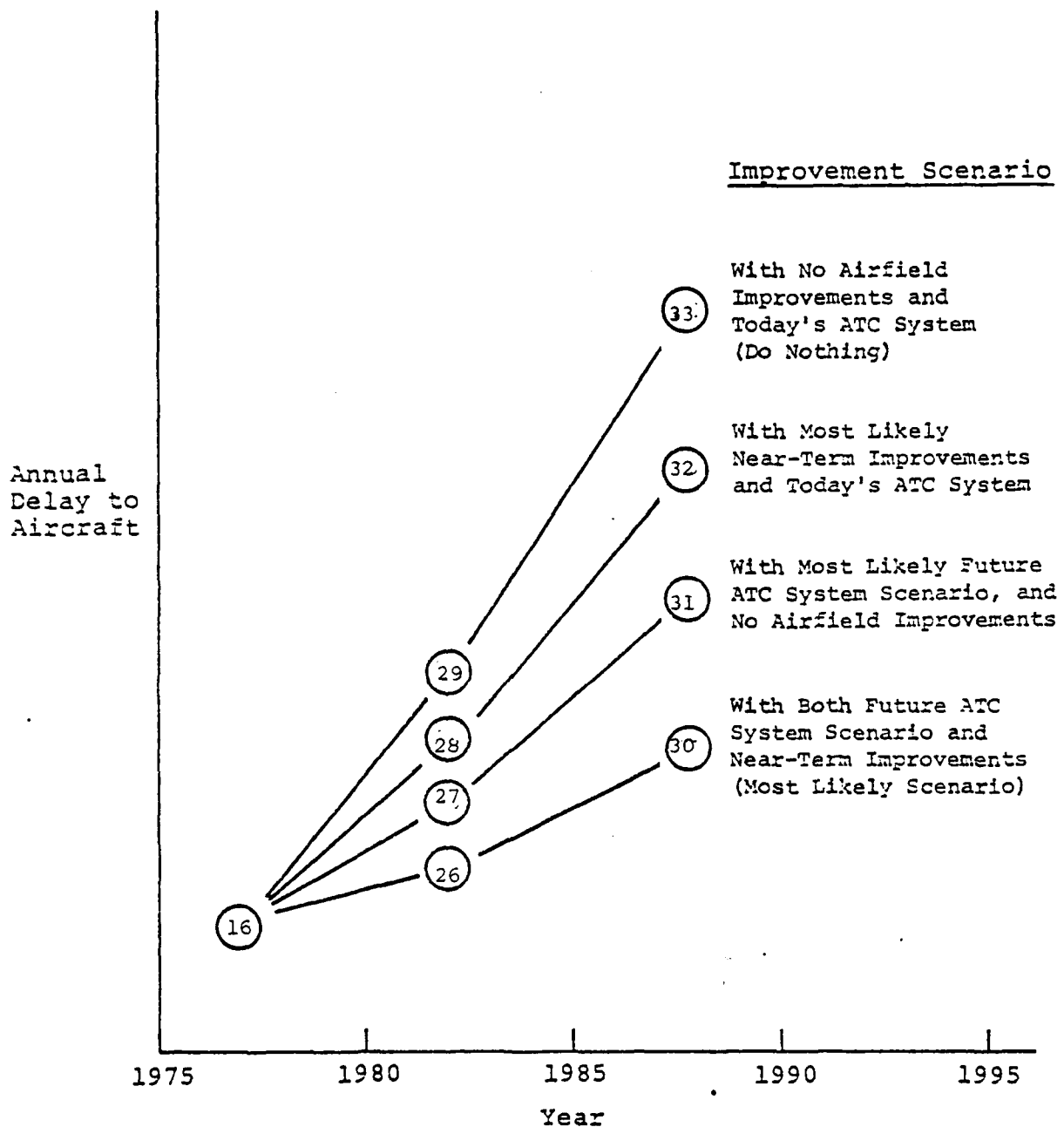
Figure III-2

HYPOTHETICAL RESULTS OF NINE
ANNUAL DELAY EXPERIMENTS
Miami International Airport
Delay Improvement Study
October 1978

III-10

IV. DATA REQUIREMENTS

Data Needs for Model Runs

The airfield simulation model and the annual delay model are recommended to be run to perform the model calibration and to prepare the delay estimates. Each model run requires a set of input data that describes the conditions being investigated.

Input Data for Airfield Simulation Model. The 38 types of input data required to run the simulation model are described below:

a.   Logistics

1.   Title: A brief description of the model application.

2.   Random Number Seeds: Each random number seed represents a daily set of variations of events. (The number of random number seeds is selected to achieve stochastic convergence of results.)

3.   Start and Finish Times: The times when the run is to start and finish.

4.   Print Options: Several options are available concerning level of detail of output, debugging statements, etc.

5.   Airline Names: The two-letter codes for each airline included in the demand data (include dummy code for general aviation or military aircraft).

6.   Processing Options: Several options are available concerning the way input data are processed, e.g., print input data only.

7.   Truncation Limits: Applies to the limits of normal distribution used in the Monte Carlo sampling technique. Defined in terms of a number of standard deviations.

8. Time Switch: Permits variation of model inputs during a model run at a particular time. (Special care must be taken when using the time switch to avoid model operation inconsistencies.)

b. Airfield Physical Characteristics

9. Airfield Network: A description of the airfield in terms of a network of links and nodes.

10. Number of Runways: The number of runways.

11. Runway Identification: Their identifiers.

12. Departure Runway End Links: The taxiway link(s) that can be occupied by aircraft prior to being given departure clearance.

13. Runway Crossing Links: The taxiway link(s) that can be occupied by aircraft prior to crossing an active runway, together with clearance times to the crossing taxiway for arriving and departing aircraft.

14. Exit Taxiway Location: The distance from the threshold of each exit taxiway, by runway.

15. Holding Areas: Those sections of taxiways or apron that are used for storing arrival aircraft that are awaiting a gate.

16. Airline Gates: The gates belonging to each airline.

17. GA Basing Areas: The basing areas for general aviation aircraft.

c. ATC Procedures

18. Aircraft Separations: Mean and standard deviation of minimum separations for each aircraft pair class for arrival-arrival, departure-arrival, departure-departure, and arrival-departure sequences (for each runway and for pairs of dependent runways).

19. Route Data: Link sequence for routes from each exit taxiway to each gate and each gate to each departure runway. Also, link sequence for routes from each exit taxiway to each holding area and from each holding area to each gate.

20. Two-Way Path Data: Link sequence for those sections of taxiway used by aircraft that may be traveling in either direction.

21. Common Approach Path(s): Length of the common approach to each runway by aircraft class.

22. Vectoring Delays: Level of airborne delay (by fix) to arrival aircraft at which holding delays start to occur.

23. Departure Runway Queue Control: Queue lengths (by runway) above which aircraft may be diverted to a different departure runway.

24. Gate Hold Control: Queue lengths (by runway) above which aircraft may be held at gate.

25. Departure Airspace Constraints: Mean and standard deviation of effect of departure airspace constraints on delays, and percentage of departures affected.

26. Departure Queue Control: Departure queue lengths above which interarrival spacings will be increased to release departures.

27. Runway Crossing Delay Control: Delays to taxiing aircraft waiting to cross an active runway above which interarrival spacings will be increased to permit crossings.

d. Aircraft Operational Characteristics

28. Exit Taxiway Utilization: Distribution of exit taxiway usage by aircraft class.

29. Arrival Runway Occupancy Times: Data on runway occupancy times for different distances from runway threshold by aircraft class.

30. Touch-and-Go Runway Occupancy Times: Mean and standard deviation by aircraft class.

31. Departure Runway Occupancy Times: Mean and standard deviation by aircraft class.

32. Taxi Speeds: Aircraft taxiing speeds for each of six taxiway link-types.

33. Approach Speeds: Mean and standard deviation by aircraft class.

34. Gate Service Times: Mean and standard deviation by aircraft class.

35. Airspace Travel Times: Undelayed travel times from approach fix to threshold and from threshold to departure fix by aircraft class.

36. Runway Crossing Times: Time for taxiing aircraft to cross active runway.

37. Lateness Distribution: Distribution of deviations from scheduled arrival times to be used in conjunction with an airline schedule (if applicable).

38. Demand: Detailed list of aircraft, including scheduled arrival and departure times, aircraft class, desired arrival and departure runway and fixes, flight type, preferred gate assignment for air carrier aircraft, and basing area for general aviation.

Four classes of aircraft are used when defining the model inputs (Classes 1, 2, 3, and 4). Each aircraft using the airport is assigned to one of the four classes. The definitions of the aircraft classes should reflect the significant groupings of aircraft at the airport that have similar operating characteristics (e.g., approach speed).

In defining the classes, it is important to note that the simulation model gate logic assumes that an aircraft can use a gate for its class number or a lower class number.

Blank data forms that may be used to assemble key input data items (Nos. 9, 18, 19, 34, 35, 37, and 38) are presented in Appendix C.

Input Data for Annual Delay Model. Fifteen types of input data required to run the annual delay model are listed below.

1. Annual Demand: Number of annual operations.

2. Group Specification: Number of day groups (up to 7); week groups (up to 52); weather groups (up to 10); and runway uses (up to 10).

3. Weekly Traffic: Proportion of total annual traffic in one week of each week group.

4. Number of Weeks: In each group.

5. Daily Traffic: Proportion of weekly traffic in one day of each group.

6. Number of Days: In each day group.

7. Weather Group Demand Factors: Ratio of demand in each weather group to the demand in the first weather group. There are as many factors as weather categories.

8. Weather Occurrences: Proportion of occurrence of each weather group in any given week group (i.e., the sum of all weather group occurrences for any week group is 1.0).

9. Hourly Runway Capacity: Hourly runway capacities for each runway use and weather combination.

10. Runway Use Occurrences: Proportion of time each runway use will be operated in the different weather conditions.

11. Hourly Traffic: Proportion of daily traffic to be distributed to each of the 24 hours.

12. Demand Profile Factor: (The proportion of peak-hour traffic in the peak 15 minutes.) This factor can take one of six values: 25, 30, 35, 40, 45, and 50.

13. Runway Use Demand Factor: Ratio of demand for each runway use to the demand for the first runway use. There are as many factors as runway uses.

14. Aircraft Mix: Mix for each runway use and weather combination. The mix should be that used to compute the hourly runway capacity.

15. User-Specified Title: Identifying alpha-numeric name to be printed in the output.

Data Sources

Data required for model runs will be developed by the Task Force, with assistance from NAFEC and PMM&Co. Planned responsibilities and procedures for development of the data are described below under the following classifications:

- Airfield Simulation Model Calibration Data

- Revisions to Simulation Model Input Data for Delay Experiments

- Annual Delay Model Baseline Data

- Revisions to Annual Delay Model Input Data for Delay Experiments

Airfield Simulation Model Calibration Data. Model calibration is designed to make the model site-specific to the Miami situation. The calibration effort involves a comparison of observed field data on aircraft flow rates, delays, and travel times with outputs from a simulation model run. The simulation model run requires a set of input data that reflects the operating conditions prevalent during the collection of the observed field data.

Therefore two types of data are needed for model calibration--
(1) model input data and (2) field data for comparison with
model outputs. The three planned sources for these two types
of data--the Task Force, Field Data, and NAFEC--are listed
in Table IV-1.

- Data from the Task Force refers to informa-
  tion currently in the possession of or avail-
  able to the Task Force. For example, estimates
  of the level of airborne delay to arrival air-
  craft at which holding starts to occur (Input
  No. 22) may be obtained from ATC personnel.

- Field data refers to information that will be
  obtained by the Task Force by field observation
  during a data collection activity. For example,
  the travel time for aircraft taxiing from gate
  to runway may be obtained by visual observation
  of the time the aircraft leaves its gate and
  the time that it reaches the runway. (Details
  of field data collection are given later in
  this chapter.)

- Data from NAFEC refers to information
  currently in the possession of or to be
  developed by NAFEC. For example, NAFEC
  will provide departure runway occupancy
  times based on the previously performed
  capacity analyses.

Revisions to Simulation Model Input Data for Delay
Experiments. Each simulation model experiment described in
Chapter III requires input data that describe the situation
being examined. The data will be based on the model calibra-
tion data described above. Revisions will be made to the model
calibration input data to reflect the conditions to be investi-
gated in each delay experiment. The revisions may impact any
of the 38 types of input.

All of the revisions to simulation model input data for delay
experiments will be developed by the Task Force, with assis-
tance from NAFEC, PMM&Co. and FAA Headquarters. No additional
field data collection is anticipated.

Table IV-1

SOURCES OF DATA FOR
AIRFIELD SIMULATION MODEL CALIBRATION

Data Type	Source
1 INPUT DATA	
a. Logistics	
1 Title	NAFEC
2 Random number seeds	NAFEC
3 Start and finish times	Field Data
4 Print options	NAFEC
5 Airline names	NAFEC
6 Processing options	NAFEC
7 Truncation limits	NAFEC
8 Time switch	NAFEC
b. Airfield Physical Characteristics	
9 Airfield network	NAFEC
10 Number of runways	NAFEC
11 Runway identification	NAFEC
12 Departure runway end links	NAFEC
13 Runway crossing links	NAFEC
14 Exit taxiway location	NAFEC
15 Holding areas	Task Force
16 Airline gates	Task Force
17 General aviation basing areas	Task Force
c. ATC Procedures	
18 Aircraft separations	Field Data
19 Route data	Task Force
20 Two-way path data	Task Force
21 Common approach paths	Task Force
22 Vectoring delays	Task Force
23 Departure runway queue control	Task Force
24 Gate hold control	Task Force
25 Departure airspace constraints	Task Force
26 Departure queue	Task Force
27 Runway crossing delay control	Task Force
d. Aircraft Operational Characteristics	
28 Exit taxiway utilization	Task Force
29 Arrival runway occupancy times	Task Force
30 Touch-and-go runway occupancy times	NAFEC
31 Departure runway occupancy times	NAFEC
32 Taxi speeds	Field Data
33 Approach speeds	Field Data
34 Gate service times	Task Force
35 Airspace travel times	Field Data
36 Runway crossing times	Field Data
37 Lateness distribution	Task Force
38 Demand	Field Data
2 OUTPUT DATA	
A Flow rates	Field Data
B Delays	Field Data
C Travel Times	Field Data

Each delay experiment involves some or all of the following types of changes from the model calibration situation:

- Study Case--the runways in use and the weather condition may differ

- Demand--the number of aircraft operations in each hour may differ

- Near-Term Improvements--improvement items may be added that impact aircraft operations

- ATC System Scenarios--a future ATC system may be added that changes ATC procedures

For example, from Table III-1 it can be seen that Experiment 21 is designed to investigate the potential benefits of a remote parking position for international arrivals. To develop the input data for this experiment, the input data for model calibration should be revised as follows.

The Study Case is changed from the calibration condition to a special study case that permits arrivals to park at the remote location. To correspond with this change, a number of model inputs must be revised--for example, the arrival taxiing routes must now connect the runways with the remote parking areas.

The Demand is changed from the calibration demand level to a level that reflects 1982 conditions. A revised schedule must be prepared that reflects forecasts of traffic increases and changes in aircraft mix that represent the Task Force view of the 1982 time period.

The ATC System Scenario that is considered most likely to be implemented in the 1982 time period is defined. Model inputs are then revised to reflect the improvement package--for example, aircraft separations may be reduced to reflect the presence of a wake vortex advisory system.

Annual Delay Model Baseline Data. Delay Experiment 17 calls for an estimate of average annual delay to aircraft under 1977 baseline conditions.

The planned sources for the 15 types of data required for the baseline run are shown in Table IV-2. No additional field data collection is anticipated. However, discussion of some of the data types will be required to help define the input definition. For example, definition of the occurrence of runway uses may involve a comparison of Task Force historical data on runway uses with data on crosswinds, ceiling, and visibility.

One of the major input data items is the hourly runway capacity associated with each baseline study case. Some of this capacity information can be derived directly from the previous capacity work of the Task Force. Additional capacity information will be required, and the hourly runway capacity model (that was previously used for Los Angeles) will be used to provide the additional capacity information. A description of this capacity model is included in Appendix A.

Revisions to Annual Delay Model Input Data for Delay Experiments. Each annual delay model experiment recommended in Chapter III requires input data that describe the situation being examined. The 1977 baseline delay experiment is described above.

Input data for the remaining experiments will be based on the input data developed for the 1977 baseline delay experiment. Revisions will be made to the baseline input data to reflect the conditions to be investigated in each delay experiment. The revisions may impact any of the 15 types of input.

All of the revisions to annual delay model input data for delay experiments will be developed by the Task Force, with assistance from NAFEC, PMM&Co., and FAA Headquarters. No additional field data are anticipated.

The annual delay model experiments involve the following types of changes in input data from the baseline condition:

- Demand

- Near-Term Improvements

- ATC System Scenarios

In many cases, these types of changes in input data are similar to the changes for the simulation model described previously.

Table IV-2

SOURCES OF BASELINE DATA FOR ANNUAL DELAY MODEL

	Data Type	Source
1	Annual demand	Task Force
2	Group specification	NAFEC
3	Weekly traffic	Task Force
4	Number of weeks in each group	NAFEC
5	Daily traffic	Task Force
6	Number of days in each group	NAFEC
7	Weather group demand factors	Task Force
8	Weather Occurrences	NAFEC
9	Hourly runway capacity	NAFEC
10	Runway use occurrences	Task Force
11	Hourly traffic	Task Force
12	Demand profile factor	NAFEC
13	Runway use demand factor	NAFEC
14	Aircraft mix	NAFEC
15	User-specified title	NAFEC

For example, the 1982 do-nothing experiment (Experiment 30) requires a change in the demand from the 1977 baseline demand and aircraft mix to the most likely 1982 demand and aircraft mix. Any corresponding changes in runway capacity are also required. Other inputs would remain unchanged, i.e., the same as the 1977 baseline.

Field Data Collection Plan

Field data are to be collected to provide input and output data for simulation model calibration. The major types of data that will be obtained are:

a. Inputs

- Airspace travel times

- Taxi times and speeds

- Demand

- Aircraft separations

b. Outputs

- Flow rates

- Delays

- Travel times

To obtain these data, field data are planned to be collected during the week of Monday, October 30, 1978. Data will be collected during peak periods on five consecutive weekdays. In the event of exceptional weather conditions or other contingencies, the data collection may extend into the following week.

The data to be obtained are the time that each aircraft in the observation period passes points on the airfield and in the airspace, as follows:

Arrival Aircraft	Departing Aircraft
Arrival Fix	Off Ramp
Runway Threshold	Departure Roll
Onto Ramp	

In addition, sample data will be obtained for the following:

- Airspace and taxiway routes

- Undelayed travel times

- Exit utilization and runway occupancy
  times

- Runway crossing times

Visual observations will be made from vantage points in the
ATC Tower (or other suitable locations) and by monitoring
appropriate radar scopes. The data will be recorded manually
on data forms and then reduced by NAFEC personnel using NAFEC
data reduction computer programs.

The number of data collection personnel required will depend
on the skills of the personnel and the available locations
for observing aircraft operations. A preliminary assessment
performed by NAFEC personnel indicates the potential need for
7 persons, plus the NAFEC supervisor and 2 clerical assistants
to help collate the data. Potential assignments for the
personnel are:

Personnel Number	Data Collection Assignment
1, 2	Arrival fix times (watching ARTS scope in TRACON)
3, 4	Arrival runway threshold time (observing from tower, a tuned to local control)
5	Departure roll times (observing from tower, and tuned to local control)
6	Ramp on and off times (observing from tower and tuned to ground control)
7	Backup for data collection and taking samples of aircraft routes, etc.

The data collection supervisor is responsible for noting de-
tails of airport operations (weather, runway use, special
events, problems, etc.) and for assuring the completeness,
clarity, and accuracy of the data collection forms. The
supervisor ensures the continued availability of controller
voice tapes (approach, local, and ground control) to assist
in clarifying any uncertainties that arise during data
reduction, and obtains the ARTS tapes, and the FAA Aircraft
Delay Report (ADR) for the data collection period. The
supervisor also arranges to receive the tower counts, PMS
reports, and weather observations for the data collection
period.

At the end of each data collection period, the supervisor
checks the forms for completeness and accuracy and then
organizes the collation of the data onto two sets of
forms--one set each for arrivals and departures--that will
show the time that each aircraft passes the fix, the runway,
and the ramp. Sample data collation forms are shown in
Figures IV-1 and IV-2. The form shown in Figure IV-1 is
used for recording arrival aircraft information. Each ob-
server of arrival aircraft records for each aircraft, in
order, the aircraft identification (e.g., UA 390), the air-
craft type (e.g., B727), and the aircraft class (A, B, C,
or D). The observer also records the identification of the
station (fix, runway, or gate) and the time (GMT, to the
nearest second) the aircraft passes or reaches the station.
A similar procedure is used for departure aircraft. Depar-
ture data are recorded on the form shown in Figure IV-2.

DATA COLLATION FORM – ARRIVALS

| DATE | AIRCRAFT IDENT. | A/C TYPE | CLASS | APPN. FIX I.D. | ARRIVAL FIX TIME | R/W I.D. | RUNWAY THRESHOLD TIME | GATE I.D. | ARRIVAL GATE TIME |

Figure IV-1

ARRIVAL DATA COLLATION FORM
Miami International Airport
Delay Improvement Study
October 1978

Figure IV-2

DEPARTURE DATA COLLATION FORM
Miami International Airport
Delay Improvement Study
October 1978

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The collated field data are then transferred to NAFEC for
data reduction to produce the desired model inputs and out-
puts. After data reduction, the model inputs and outputs
are used in the model calibration. It is planned that the
data will be reviewed by the Task Force during the second
Task Force meeting prior to use of the data for model
calibration.

Appendix A

MODELS AVAILABLE TO TASK FORCE

This appendix provides an overview of the models that are
available to assist the Task Force in computing delays to
aircraft.

The PMM&Co. airfield simulation model is available for com-
putations of hourly and/or daily delays to aircraft. The
simulation model also computes aircraft flow rates and
travel times.

The annual delay model is available for computations of
annual delays to aircraft. The annual delay model also
computes distributions of average aircraft delays.

A number of additional models are also available to the Task
Force, including (1) a weather model to analyze weather occur-
rence at an airport based on raw airport climatological data
from the National Weather Records Center, and (2) an analyti-
cal runway capacity model that computes estimates of hourly
runway capacity.

I.   AIRFIELD SIMULATION MODEL

The PMM&Co. airfield simulation model contains a set of
logic statements that describe the significant movements
performed by aircraft on the airfield and in the adjacent
airspace. The simulation model operates by tracing the
path of each aircraft through space and time on the airfield
and adjacent airspace. The airfield is represented by a
series of links and nodes depicting the paths that an air-
craft could follow. The traces of the paths of all aircraft
are made by continually advancing clock time and recording
the new location of the aircraft. The records of aircraft
movement are then processed by the model to produce desired
outputs including delays, travel times, and flow rates.

The PMM&Co. airfield simulation model is a critical events
model that employs Monte Carlo sampling techniques. Vari-
able time increments are used as the time flow mechanism;
clock time is advanced by the amount necessary to cause the
next most imminent (i.e., critical) event to take place.
Running time for the model, therefore, depends on the
levels of aircraft demand (and the size of the airfield)
for any particular application.

The use of Monte Carlo sampling techniques permits the day-
to-day variations encountered in real life to be simulated
by the model. Certain of the model parameters are stochastic
(time variant and random) in nature. For example, arrival
aircraft approach speeds will vary from day to day for any
given aircraft depending on such factors as payload, wind,
and pilot technique. The distribution of these vaiations
can be approximated by the normal distribution. The model
assigns arrival aircraft approach speeds by sampling values
from a normal distribution with mean and standard deviation
specified by the user. Other stochastic model parameters are:

- Arrival/arrival separations

- Departure/arrival separations

- Arrival/departure separations

- Departure/departure separations

- Arrival runway occupancy time

- Touch-and-go runway occupancy time

- Departure runway occupancy time

- Exit taxiway choice

- Gate service time

- Arrival aircraft deviation from schedule

Because of the modular structure of the model, analysis of the total airfield or its individual components can be performed by manipulation of the model inputs. This approach is more flexible and efficient than having separate submodels for the individual components and a composite model for the total airfield.

In the following paragraphs, further details of simulation model logic are described as follows:

- Movement of aircraft—description of the progress of an aircraft through the airfield system.

- Runway and airspace operations—description of ATC algorithms that separate pairs of aircraft on the runways and in the airspace.

- Taxiing operations—description of model logic that processes aircraft on taxiways.

- Gate operations—description of model logic that processes aircraft in the apron-gate area.

Movement of Aircraft

Arrival aircraft commence at the appropriate arrival fixes in accordance with generated demand inputs. For each arrival aircraft, approach speeds are assigned from an empirical distribution according to the class of the aircraft. For each arrival pair, interarrival times, final approach speeds, and wake turbulence characteristics are checked so that sufficient separation exists on the common approach path. (The length of the common approach path is specified by the user.) As each aircraft arrives over the threshold, an exit taxiway and associated runway occupancy time are assigned to the aircraft.

The aircraft's routing to the gate or basing area is established in the following manner. As an air carrier aircraft exits the runway, a check is made on the availability of a gate of the correct size belonging to the airline under

A-2

consideration.   In the event a gate is not available, the
aircraft is routed to a holding area where further checks
on gate availability are made.   In the case of general avia-
tion or military aircraft, the aircraft's route to the
basing area is assigned on the basis of the exit taxiway used
and the location of the basing area.

Once an aircraft's route to the gate or basing area has been
established, the aircraft is moved along its route from
link-to-link on the airfield network.   Checks are made at
each link to determine whether the next link on the route
is available or occupied by another aircraft.   If the next
link is occupied, the aircraft is not moved until the link
is vacated.   Thus, the travel time is increased for the
particular aircraft, and delay is incurred.

When the aircraft reaches its gate, a gate occupancy time
is assigned from empirical distributions and is added to
the gate arrival time.   This information, when compared
with the scheduled departure time, determines the earliest
time when the aircraft could leave the gate.   The empirical
distributions for gate occupancy time may reflect the typi-
cal bunching of the schedules of air carrier departures.
When an aircraft is ready to leave the gate, a check is
made to ensure that the ramp area is clear for push-back.
The route to the departure runway is determined by the
aircraft's basing area or gate location, the aircraft class,
and the departure runways in use at that particular time.

In the case of general aviation or military aircraft, when
the aircraft reaches the basing area, it is assumed to be
parked and to have left the system.   This assumption is
necessary because of the unstructured nature of general
aviation or military operations on the apron.   The flow of
aircraft from the basing area is generated from the demand
inputs by producing an expected departure time from the
basing area for each general aviation aircraft.   The route
to the departure runway is established by the location of
the basing area and the departure runways in use.

When an aircraft reaches the threshold of the departure run-
way, compliance with ATC procedures is checked and confirmed
before the aircraft is cleared for takeoff.   The following
checks are made:

- Has the previous dependent arrival cleared
  the runway?

- Is there sufficient separation from the next
  incoming dependent arrival?

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• Is there sufficient separation from the previous dependent departure?

If all of these checks are positive, the aircraft is cleared for takeoff.

Runway and Airspace Operations

An ATC algorithm allows the specification of separations between aircraft on the same runway and on dependent runways. These separations are defined for an arrival following an arrival, a departure following an arrival, a departure following a departure, and an arrival following a departure. For arrivals or departures on each runway, the model checks that sufficient separation exists between the aircraft under consideration and any other aircraft operation on the same runway or any dependent runway. In determining the time separation between a pair of successive arrival aircraft at the runway threshold, the model takes into account:

1. The required air traffic control separation for the aircraft pair.

2. The final approach velocity of each aircraft.

   a. If the trail aircraft is faster than the lead aircraft, the required arrival separation is assured at the runway threshold.

   b. If the trail aircraft is slower than the lead aircraft, the required arrival separations are set up at the beginning of the common approach path. The amount of time the trail aircraft falls behind is included in the time separation over threshold for the aircraft pair.

3. Runway occupancy. Only one aircraft is permitted to occupy the runway at any given time.

The model determines a time separation between a pair of successive departure aircraft which takes into account the required air traffic control separation by aircraft pair. The model will permit a departure to roll on a runway (thus

interweaving arrivals and departures) when all of the following conditions have been fulfilled:

1.   The previous arrival aircraft has exited.

2.   When the departure begins to roll, the next arrival is far enough from the threshold for the departure to clear the runway before the arrival is over its threshold.

3.   Sufficient separation from the previous departure exists.

For pairs of intersecting runways, the user must also input arrival-departure separations so the model checks that the arrival aircraft has cleared the intersection before a departure that is being cleared on the intersecting runway.

Several special ATC features are incorporated into the simulation model logic. One ATC feature included in the model increases arrival aircraft spacings on final approach to allow departure queues to be dissipated. The length of the departure queue (number of aircraft) at which the interarrival spacing is increased and the desired interarrival spacing (minutes) must be specified.

Another ATC feature included in the model searches departure runways for congestion before assigning a departure runway to an aircraft leaving its gate. A runway is selected that minimizes delay. If runway congestion is too heavy, the aircraft is held on the gate until the congestion reduces.

Taxiing Operations. The normal operation of the model moves aircraft from link to link on a predetermined path which is defined in terms of a series of links. The model performs a check to ensure that the next link on the path is not occupied by another aircraft before moving on to the link. It is assumed in the logic that the taxiway is used by aircraft moving in the same direction at all times, unless the user specifies to the contrary.

Taxiways on which aircraft may taxi in both directions are defined as two-way taxiways. These taxiways, which are defined by the user, may occur at several places on the airfield and are often found between pier fingers at a terminal building. The model checks aircraft movements to determine if the aircraft is about to enter a two-way path. In the event that an aircraft is about to enter a two-way path, the model then checks along the path to determine if there

are other aircraft on the path that may be moving toward a
potential conflict. If a potential conflict exists, the
aircraft for which the check is being made is delayed until
the conflict condition no longer exists.

If an aircraft is about to taxi across an active runway,
the model performs certain checks in accordance with ATC
procedures to determine if it is safe for the aircraft to
cross. Priority is always given to aircraft operating
on the runway.

Gate Operations. Once a gate is assigned to an arriving
air carrier aircraft, the model moves the aircraft from
link to link on the network to the gate, observing a first-
come-first served rule in the event of conflicts (except
for taxiways across active runways). For those airfields
having terminal buildings with pier fingers, a "two-way path"
will often serve the gates between any two pier fingers.
Thus, prior to entering the two-way path, the model will
check for aircraft moving either toward or away from a par-
ticular gate on the path. In the event an aircraft is moving
on the path toward a gate (i.e., away from the arrival air-
craft for which the check is being performed), the model
permits the arrival aircraft to taxi on the path toward
its gate in "platoon fashion" similar to real-life opera-
tions. If an aircraft is taxiing from the gate or is in
the process of pushing back, the arrival aircraft is held
until the departing aircraft is clear of the two-way path.

When the model detects that an aircraft is ready to push back
from the gate, a check is performed to see if the aircraft
will push back onto a two-way path. If it will push back
onto a two-way path, the model then checks for aircraft on
the two-way path and permits "platooning" in a similar
fashion as described for arrivals. If there is an aircraft
taxiing toward the area which the departing aircraft will
occupy during push-back, the aircraft is delayed on the
gate until the arrival aircraft has cleared the area in
question.

Procedure for Application of Model

The following is a typical procedure for applying the simu-
lation model to evaluate aspects of airfield operations:

 • Establish the conditions under which the
   application will be performed.

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- Visit site to obtain first-hand familiarization with airfield operations.

- Assemble input data from (a) discussions with ATC, airport sponsor, and airline personnel; (b) historical data; and (c) field data collection as necessary. The preprocessor models should be used to prepare demand and routing data in machine compatible format.

- Coordinate input data with ATC, airport sponsor, and airline personnel.

- Load input data and use output options that permit input data to be reviewed before execution. Correct as necessary.

- Perform trial model run using one random number seed, with all diagnostic print options functioning, to check that the model is operating correctly for the input data that is being used. Correct as necessary.

- After confidence in model inputs has been established, suppress diagnostic print options before making the model runs for evaluation of airfield improvements.

- Determine level of output detail required for evaluation and specify appropriate print options.

- Perform model runs.

- Use postprocessor models as required to develop detailed statistical information on aircraft delays.

Inputs

The airfield simulation model was developed to be applicable to the range of airfield configurations currently in existence and to those configurations that are likely to evolve in the future. Consequently, the model does not contain any airport-specific or aircraft-class-specific data; all data are input.

Thus, the model may be applied to airfields ranging from a nontower general aviation field to an airfield with the complexity of Chicago O'Hare International Airport. It should be noted, however, that simulation model application is relatively expensive because of the model's complexity and the volume of input data required to run it. Therefore, the model is most often applied at airports with more complex airfield layouts that experience significant aircraft delays.

The 38 types of input data required to run the simulation model are listed below:

a. Logistics

    1. Title: A brief description of the model application.

    2. Random Number Seeds: Each random number seed represents a daily set of variations of events. (The number of random number seeds is selected to achieve stochastic convergence of results.)

    3. Start and Finish Times: The times when the run is to start and finish.

    4. Print Options: Several options are available concerning level of detail of output, debugging statements, etc.

    5. Airline Names: The two-letter codes for each airline included in the demand data (include dummy code for general aviation or military aircraft).

    6. Processing Options: Several options are available concerning the way input data are processed, e.g., print input data only.

    7. Truncation Limits: Applies to the limits or normal distribution used in the Monte Carlo sampling technique. Defined in terms of a number of standard deviations.

    8. Time Switch: Permits variation of model inputs during a model run at a particular time. (Special care must be taken

when using the time switch to avoid
model operation inconsistencies.)

b.   Airfield Physical Characteristics

9.   Airfield Network: A description of the
airfield in terms of a network of links
and nodes.

10. Number of Runways: The number of runways.

11. Runway Identification: Their identifiers.

12. Departure Runway End Links: The taxiway
link(s) that can be occupied by aircraft
prior to being given departure clearance.

13. Runway Crossing Links: The taxiway link(s)
that can be occupied by aircraft prior to
crossing an active runway, together with
clearance times to the crossing taxiway
for arriving and departing aircraft.

14. Exit Taxiway Location: The distance from
the threshold of each exit taxiway, by
runway.

15. Holding Areas: Those sections of taxiways
or apron that are used for storing arrival
aircraft that are awaiting a gate.

16. Airline Gates: The gates belonging to
each airline.

17. GA Basing Areas: The basing areas for
general aviation aircraft.

c.   ATC Procedures

18. Aircraft Separations: Mean and standard
deviation of minimum separations for each
aircraft pair class for arrival-arrival,
departure-arrival, departure-departure,
and arrival-departure sequences (for each
runway and for pairs of dependent runways).

19. Route Data: Link sequence for routes from
each exit taxiway to each gate and each
gate to each departure runway. Also, link

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sequence for routes from each exit taxiway
to each holding area and from each holding
area to each gate.

20. Two-Way Path Data: Link sequence for
those sections of taxiway used by air-
craft that may be traveling in either
direction.

21. Common Approach Path(s): Length of the
common approach to each runway by air-
craft class.

22. Vectoring Delays: Level of airborne delay
(by fix) to arrival aircraft at which
holding delays start to occur.

23. Departure Runway Queue Control: Queue
lengths (by runway) above which aircraft
may be diverted to a different departure
runway.

24. Gate Hold Control: Queue lengths (by
runway) above which aircraft may be
diverted to a different departure
runway.

25. Departure Airspace Constraints: Mean and
standard deviation of effect of departure
airspace constraints on delays, and per-
centage of departures affected.

26. Departure Queue Control: Departure queue
lengths above which interarrival spacings
will be increased to release departures.

27. Runway Crossing Delay Control: Delays
to taxiing aircraft waiting to cross
an active runway above which interarrival
spacings will be increased to permit
crossings.

d. Aircraft Operational Characteristics

28. Exit Taxiway Utilization: Distribution
of exit taxiway usage by aircraft class.

29. Arrival Runway Occupancy Times: Data on
runway occupancy times for different dis-
tances from runway threshold by aircraft
class.

30. Touch-and-Go Runway Occupancy Times:
    Mean and standard deviation by aircraft
    class.

31. Departure Runway Occupancy Times: Mean
    and standard deviation by aircraft class.

32. Taxi Speeds: Aircraft taxiing speeds
    for each of six taxiway link-types.

33. Approach Speeds: Mean and standard
    deviation by aircraft class.

34. Gate Service Times: Mean and standard
    deviation by aircraft class.

35. Airspace Travel Times: Undelayed travel
    times from approach fix to threshold and
    from threshold to departure fix by air-
    craft class.

36. Runway Crossing Times: Time for taxiing
    aircraft to cross active runway.

37. Lateness Distribution: Distribution of
    deviations from scheduled arrival times
    to be used in conjunction with an airline
    schedule (if applicable).

38. Demand: Detailed list of aircraft
    including scheduled arrival and depar-
    ture times, aircraft class, desired
    arrival and departure runway and fixes,
    flight type, preferred gate assignment
    for air carrier aircraft, and basing
    area for general aviation.

Four classes of aircraft are used when defining the model
inputs (Classes 1, 2, 3 and 4). Each aircraft using the
airport is assigned to one of the four classes. The defi-
nitions of the aircraft classes should reflect the significant
groupings of aircraft at the airport that have similar operat-
ing characteristics (e.g., approach speed).

In defining the classes, it is important to note that the
simulation model gate logic assumes that an aircraft can use
a gate for its class number or a lower class number.

At the beginning of each run, the model assumes that there
are no aircraft on the airfield. Aircraft are generated at

various locations on the airfield and in the adjacent air-
space according to the demand schedule. To obtain relevant
data for the time period being simulated, it is recommended
that preloading be used. Preloading may be accomplished in
one of two ways:

1. Start the simulation run approximately
    one hour ahead of the period of interest,
    using appropriate demand levels for that
    hour, or

2. Include in the demand schedule the aircraft
    that may be parked at the various airline
    gates at the beginning of the period of
    interest.

The first alternative is normally preferred if the period of
interest being simulated is relatively short, i.e., one or
two hours. If the period being simulated is greater than
two hours, then the second alternative may be used.

Tests on the convergence of the model's stochastic parameters
have indicated that it is normally desirable to use at least
ten random number seeds when making a model run. Ten random
number seeds, in effect, simulate the day-to-day variations
of aircraft operations on ten days, for the period of the
day under consideration.

Outputs

The primary outputs from the delay model are aircraft delays,
travel times, and flow rates. In addition, the locations of
aircraft delays are shown and departure runway queuing sta-
tistics are produced. The model outputs may be obtained in
two levels of detail.

Summary Output. The summary output, which is automatically
produced by the program together with a listing of the output
data, contains the following information for each hour of the
model run.

●   Flow rates on runways, taxiways, and gates
    by aircraft class for arrival and departure
    aircraft.

●   Delays (in minutes) for arrival and depar-
    ture aircraft. For arrival aircraft, air
    delays are broken down into holding and

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vectoring delays by approach fix and by runway, while ground delays are identified as taxi-in, runway crossing, and gate delays. For departure aircraft, ground delays are broken down into gate, taxi-out, runway crossing, and runway delays; departure gate delays (gate holds) and runway delays are broken down by cause (i.e., runway congestion and airspace congestion).

o   Travel times (in minutes) for arrival and departure aircraft are given by fix, runway, and aircraft class.

o   In addition to the summary information noted above, delays are provided for individual arrival and departure aircraft and for the location of those delays, (i.e., by link number). It is not meaningful to provide these data as average values over a number of random number seeds. Therefore, individual aircraft delays and link delays are provided for the last random number seed specified in the input data.

Detailed Output. The detailed output is a time-ordered record of the movements of individual aircraft as they move from link to link in the network. The information contained in the detailed output for each individual aircraft movement includes the following:

o   Aircraft identification number

o   Aircraft state

o   Aircraft class

o   Gate assignment (where applicable)

o   Time over threshold (for arrival)

o   Gate service time (where applicable)

o   Gate departure time

o   Simulation clock time

o   Location of aircraft

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All times are given in hours, minutes, and seconds except for times included in error messages and diagnostics which are given in minutes.

In addition to this detailed information, the number of aircraft in the queue for a departure runway is printed out each time an aircraft joins the queue and each time an aircraft is given clearance for takeoff. The information contained in this detailed output permits the user to follow the movement of individual aircraft and identify the cause(s) of the delay that an aircraft may experience.

II. ANNUAL DELAY AGGREGATION MODEL

Annual delay is made up of the sum of the individual aircraft delays that occur in each hour of the 365 days of the year. The annual delay aggregation model is an analytical model that takes information on airfield demand and capacity, computes hourly and daily delay, and aggregates daily delays to compute total annual delay, average delay per aircraft, and the distribution of delays.

The annual delay aggregation model computes hourly delays for a number of conditions that are representative of the seasonal and daily variations in demand, weather, runway use, and capacity.

The model assumes that the variations in demand over the year can be characterized by a number of representative daily demands. The number of representative daily demands used in an analysis for a particular airport depends on (1) the variability of daily and hourly demands through the year, and (2) the desired level of refinement in estimating annual delay. The model is capable of accommodating up to 365 daily demands, if desired or necessary.

The model converts annual demand into representative hourly demands using three demand distributions:

- Week-group distribution of demand

- Day-group distribution of demand

- Hourly distribution of demand

A week group is a set of weeks that have similar demand and weather characteristics. The week-group distribution of demand provides the proportion of annual demand that occurs in each week of a week group.

A day group is a set of days within a week that have similar demand characteristics. The day-group distribution of demand provides the proportion of weekly demand that occurs in each day of a day group.

The hourly distribution of demand provides the proportion of daily demand that occurs in each hour of the day.

The occurrence of different weather conditions and runway uses, and the hourly runway capacities corresponding to these occurrences, are provided as input to the model. These inputs are used to determine hourly demand and capacity.

Hourly delays are calculated for each hour of the year using delay curves built into the model. The average delay per operation for the year is computed by aggregating these hourly delays.

The three major steps in the model's calculation process are summarized as follows:

1. Determine each representative daily demand as follows:

    a. Identify annual demand

    b. Estimate demand for each week group

    c. Estimate daily demand for each week group

    d. Determine percent of time each weather condition occurs in each week group

    e. Determine number of days represented (i.e., number of days in each week group multiplied by percent of time each weather condition occurs)

2. Calculate daily delay for each representative daily demand as follows:

    a. Identify different runway uses which may be used

    b. Determine percent of time each runway use occurs

    c. Determine percent of daily demand occurring in each hour for each runway use

    d. Calculate demand in each hour of the day

    e. Calculate hourly capacity for each runway use

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f.   Determine hourly delay for each hour
      for each runway use

g.   Determine daily delay for each runway
      use

h.   Estimate daily delay for each repre-
      sentative daily demand

3. Estimate annual delay from daily delays.

Inputs

The inputs for the annual delay aggregation model are stored
in a file for processing by the model.

The five types of input data required to run the annual delay
model are listed below.

1. Annual Demand: Number of annual operations.

2. Group Specification: Number of day groups
    (up to 7); week groups (up to 52); weather
    groups (up to 10); and runway uses (up to 10).

3. Weekly Traffic: Proportion of total annual
    traffic in one week of each week group.

4. Number of Weeks: In each group.

5. Daily Traffic: Proportion of weekly traffic
    in one day of each group.

6. Number of Days: In each day group.

7. Weather Group Demand Factors: Ratio of
    demand in each weather group to the demand
    in the first weather group. There are as
    many factors as weather categories.

8. Weather Occurrences: Proportion of occur-
    rence of each weather group in any given
    week group (i.e., the sum of all weather
    group occurrences for any week group
    is 1.0).

9. Hourly Runway Capacity: Hourly runway
    capacities for each runway use and weather
    combination.

10. Runway Use Occurrences: Proportion of time each runway will be operated in the different weather conditions.

11. Hourly Traffic: Proportion of daily traffic to be distributed to each of the 24 hours.

12. Demand Profile Factor: (The proportion of peak-hour traffic in the peak 15 minutes.) This factor can take one of six values: 25, 30, 35, 40, 45, and 50.

13. Runway Use Demand Factor: Ratio of demand for each runway use to the demand for the first runway use. There are as many factors as runway uses.

14. Aircraft Mix: Mix for each runway use and weather combination. The mix should be that used to compute the hourly runway capacity.

15. User-Specified Title: Identifying alpha-numeric name to be printed in the output.

Outputs

The outputs from the model are as follows:

- Average annual delay per aircraft

- Total annual delay to aircraft

- Distribution of average aircraft delays

The distribution of annual delay is computed and listed by time interval. Each time interval is printed only if the interval contains delayed aircraft.

III. OTHER ANCILLARY MODELS

A number of additional models can be used in the Task Force efforts to accomplish the analyses more efficiently, to permit greater depth of analysis, and to broaden the types of information that can be provided for evaluation of alternatives, including:

- A demand schedule preprocessor model that permits generation of aircraft movement schedules from Official Airline Guide (OAG) data and other data sources in a form that is compatible with the simulation model input requirements.

- A routing generator preprocessor model that simplifies the procedure of specifying aircraft routings on the airfield.

- Two postprocessor models that assist in interpreting the simulation model outputs. The postprocessors can generate statistics on mean values, standard deviations, and confidence limits, and can provide detailed distributions for user-specified parameters. Graphical plots of various kinds can also be developed.

- An Automated Radar Terminal System (ARTS) data model that analyzes data output from Federal Aviation Administration ARTS data extraction and reduction programs and processes the information into a format that is compatible with the simulation model input requirements.

- A weather model to analyze weather occurrence at an airport based on raw airport climatological data from the National Weather Records Center. This model permits development of wind, ceiling, and visibility data for input to airfield delay studies.

- A runway capacity model that computes hourly runway capacity based on user-provided inputs, including runway use, weather, percent arrivals, and aircraft mix.

Demand Schedule Preprocessor Model

The airfield simulation model requires input data covering aircraft demand on the airfield system. Data requirements are:

1. Aircraft identifier (e.g., flight number for air carrier aircraft)

2. Aircraft class

3. Arrival time

4. Departure time

5. Arrival fix and runway

6. Departure fix and runway

7. Preferred gate assignment (for air carrier aircraft) or basing area (for general aviation and military aircraft)

At air carrier airports, one available source of demand information is the Official Airline Guide (OAG), which is available in hard copy and in magnetic tape format. The OAG data contain data items 1, 2, 3, and 4 listed above.

The demand schedule preprocessor model extracts these items from the OAG data and combines them with other data to provide demand data for scheduled air carrier and air taxi operations. The output from the model can include a printed schedule and punched cards suitable for use with the PMM&Co. airfield simulation model.

Three sets of inputs are required:

- OAG arrival data

- OAG departure data

- User-specified data

Model output is the demand schedule, printed out or punched on cards as the user specifies.

Routing Generator Preprocessor Model

Routing data requirements for the airfield simulation model consist of defining the typical paths aircraft use between the runways and the apron areas. More specifically, routes have to be defined for each exit taxiway/gate (or basing area) combination and for each gate (or basing area)/departure-runway combination. In addition, if holding areas or penalty boxes are used, routes have to be defined to and from these locations. The routing generator preprocessor model minimizes the effort involved in identifying the many routes that are typically used at a large air carrier airport.

Input to the preprocessor model consists of defining typical routes in a fashion similar to that required for the airfield simulation model. However, the logic of the preprocessor model is such that once a particular sequence of links is defined on a route, it is possible to abbreviate subsequent routes that contain the sequence by specifying the first link, a minus sign ("-"), and the last link of the sequence.

When the routing preprocessor model encounters a minus sign, it assumes the link numbers adjacent to the minus sign are part of a previously defined route. The program then searches through previous routes until it finds one containing these two links. It assumes that the complete route includes all links in between these links.

The model then generates the proper route. This program considerably reduces the amount of work required to identify the routes and prepare the input data for the airfield simulation model. The output from the preprocessor model is formatted such that it is directly usable as input to the airfield simulation model.

Postprocessor Models

Varying levels of detail may be obtained from the PMM&Co. airfield simulation model. Even though these levels of detail are adequate for many applications, in some situations further levels of detail may be desirable. Examples include aircraft delays by airline and aircraft type. Two postprocessor models are available that use detailed information on individual aircraft movements generated by the airfield simulation model to provide additional analytic capabilities. One is a statistical postprocessor that generates frequency distributions, bar charts, and other data. The second is a graphical postprocessor.

The statistical postprocessor model utilizes the Statistical
Package for the Social Sciences (SPSS) computer programs to
derive user-specified statistical measures such as the mean,
standard deviation, and confidence limits for a given param-
eter, and distributions of delay values, travel times, and
queue lengths. SPSS is maintained as an application package
by the Control Data Corporation at their Western Cybernet
Center.

The statistical postprocessor program uses the FREQUENCIES
subprogram contained in the SPSS package. The user manipu-
lates various SPSS statements to control both the type of
output, such as delays to arrival aircraft, and the form of
the output, statistical measures, bar graphs, etc. The
postprocessor is structured to use a specific output file
from the PMM&Co. airfield simulation model as the input for
statistical analysis.

The statistical postprocessor is currently structured to
print three sets of outputs:

- Frequency tables
- Frequency bar graphs
- Statistical measures

These outputs can be obtained for any combination of delays
and travel times for arrivals and departures. For the fre-
quency tables and bar graphs the output data are rounded to
the nearest integer. The frequency table output includes:

- Absolute frequencies
- Relative frequencies
- Adjusted frequencies
- Cumulative frequencies

The statistical measures include:

- Mean
- Mode
- Median
- Standard deviation
- Variance
- Kurtosis
- Skewness
- Range
- Minimum
- Maximum
- Sum
- Standard error of the mean
- Coefficient of variance
- 95% confidence interval for the mean

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- Number of valid cases
- Number of missing cases

The graphic postprocessor model produces graphic plots of
various data. Data may be delay values, travel times, or
other data obtained from the PMM&Co. airfield simulation
model. The postprocessor is structured to take an output
file from a single run of the airfield simulation model and
plot total arrival and departure delays by hour.

The graphic postprocessor model consists of two computer
programs that utilize the DISSPLA plotting software devel-
oped by Control Data Corporation. The first program reads
in the data and uses DISSPLA routines to build the plot
file. The second program performs the plotting manipula-
tions.

To build the plot file, the first program generates the
proper inputs for the plotting routines. Maximum values and
step sizes for both sets of data are determined, and arrays
are established that contain the plotting points. Then, a
series of plotting routines are called to develop axes,
labels, titles, and the curves themselves. The output file
is then cataloged for use as input for the second program.

The second program takes the output of the first program and
creates a file that is graphically plotted by a CALCOMP
plotter. The program also controls the disposition of the
plots.

The output from the first plotting program lists the hours
that will be plotted along the x-axis, the number of hours
to be plotted, and the actual delay values to be plotted.

The output from the second program is a listing of the control
cards for plotting and the actual plot.

ARTS Data Model

The ARTS data model analyzes output from Federal Aviation
Administration ARTS III data extraction and reduction pro-
grams, and processes the information into a format that is
compatible with inputs required by the airfield simulation
model.

Capacities and delays at airports depend largely on aircraft
separations which reflect operational procedures and air
traffic control requirements. The Automated Radar Terminal
System (ARTS) tracks individual aircraft. Data contained on
Federal Aviation Administration ARTS III magnetic tapes

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include aircraft location, identity, altitude, and time of observation. The PMM&Co. ARTS data model uses such data to determine relevant statistics on:

- Aircraft separation (both arrivals and departures)

- Approach and departure speeds

- Air traffic distribution over runways and coordinate fixes

- Utilization of each runway and coordinate fix

The ARTS data model requires three types of input from the user.

The first type of input is the output data from the Federal Aviation Administration ARTS III extraction and reduction programs. This tape records the movements of each aircraft studied, and is expected to be available from FAA. The information required by the PMM&Co. ARTS data model includes: aircraft identity; operation type (i.e., arrival or departure); the time that an aircraft passes through a coordinate fix, and the name of the coordinate fix; the time that an aircraft is at the runway threshold; and the runway used.

The second type of input is a correspondence table between aircraft identity and aircraft class. The model uses this information in compiling separation, velocity, and traffic distribution statistics by aircraft class. Such a correspondence table can usually be constructed using the Official Airline Guide. This table is read according to 8(1X,A6,1X,A1) format. Each card will contain eight pairs of aircraft identity (airline and flight identifiers) and the associated aircraft class.

The third type of input covers some airport-specific information. In all, 12 different items are required, including the number of runways and fixes.

The ARTS model produces information that can be used as inputs to the airfield simulation model. These include:

- Arrival-arrival separation distributions over runways and over fixes classified by aircraft class

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- Departure-departure separation distributions over runways and over fixes classified by aircraft class

- Approach-speed distributions for arrivals and takeoff speeds for departures by aircraft class

- Utilization of each runway and fix

- Aircraft mix for each runway and fix

Weather Model

The weather model extracts and processes relevant information from airport climatological data compiled on magnetic tape by the National Weather Records Center in Asheville, North Carolina. The model analyzes weather data and presents pertinent information for airport planning purposes. The model first reads data on the weather center tape and then screens and transfers them to another magnetic tape in a form suitable for manipulation and analysis. Depending on the options the user chooses, the model can produce one or more sets of data on wind, ceiling, and visibility.

Analyzing aircraft operations at airports often requires detailed knowledge of how different weather conditions are distributed over a year. The National Weather Records Center keeps records of weather observations for most major U.S. airports. The PMM&Co. weather model manipulates data from such records to:

- Calculate and tabulate crosswind components on a runway or, in the case of a multiple-runway airport, on both primary and secondary runway orientations. The observations can be tabulated by hour of day and by month of year for specified crosswind velocity ranges.

  The crosswind components are computed knowing information on wind direction and speed, and true runway orientation. This information is available by hour of the day and by month of the year and is cross-classified with information on ceiling and visibility.

- Tabulate the occurrence of various ceiling/visibility conditions by time of day and month of year.

- Estimate the number of aircraft that are delayed, diverted, or cancelled during wind conditions which close the airport. The frequency distribution of consecutive hours of specific weather conditions can also be tabulated to help the user in determining delays, diversions, and cancellations.

  The number of arrival aircraft delayed, diverted, or cancelled is computed by comparing the weather records of individual days with a schedule of aircraft demand. The number of aircraft demanding service within specified excessive crosswind conditions is then computed and output.

  The model logic allocates delays to aircraft which are subject to airport closures of one hour or less. For aircraft subject to airport closures of more than one hour, 20% are considered diverted and 80% cancelled, except for operations in the last hour which are all delayed.

  This portion of the model was developed in response to a site-specific airport analysis requirement. In general, the handling of the impacts of airport closures is a complex problem which is best examined in a site-specific manner. Therefore, modifications to this portion of the model may be appropriate for analysis at other airports.

- Print out wind rose tables at a specific airport. This can be performed for any user-specified ceiling and visibility conditions and for any duration in a day (e.g., the 17-hour period between 0700 hours and 2400 hours, or the entire 24-r day).

  Wind rose tables can be deve¹⸱ᵈ⸱ ⸱ny specified sets of wind speed ranges and are presented for 16 points of the compass.

The occurrence of various ceiling and visibility conditions is given for up to seven different sets of conditions.

Three types of input are required to exercise the weather model.

All analyses performed by the weather model require the
first type of input, which consists of three elements:

- The years for which weather data will
  be analyzed

- A header card containing the name of
  the airport and/or the run description

- Three groups of ceiling and visibility
  conditions for use in the analysis

The second type of input is a set of weather data for the
airport being studied. The weather data are generally
stored on magnetic tapes which can be obtained from the
National Weather Records Center in Asheville, North Carolina.

The third type of input relates to the kind of analysis to
be performed. A total of six options are available for
analysis and different inputs are required in each case. The
analysis options available are:

1. Data tape screening
2. Delay, diversion, and cancellation
3. Primary runway crosswind component
4. Primary and secondary runway crosswind component
5. Wind rose tables
6. Ceiling and visibility

The output from any individual computer run depends on the
options selected for analysis. Output for each of the
options is described in the following paragraphs.

Option 1--Data Tape Screening

The output of Option 1 is the screened and processed weather
data for use with all other options.

Option 2--Delay, Diversion, and Cancellation

For the specified time period and crosswind speed ranges,
the output of Option 2 gives the date, duration, and wind
velocity for all occasions with excessive crosswind. In
addition, for the specified demand schedule, the number of
aircraft delayed, diverted, or cancelled is given for each
occasion.

Option 3--Primary Runway Crosswind Components

For the specified runway azimuth and crosswind speed ranges, the output of Option 3 gives the number of weather observations in each crosswind speed range by hour of day and by month. This information is cross-classified with the number of weather observations in three specified ceiling and visibility conditions.

Option 4--Primary and Secondary Runway Crosswind Components

Output of Option 4 is identical to that of Option 3 except that the output is presented for both the primary and secondary runway azimuth, and that there is no classification according to ceiling and visibility conditions.

Option 5--Wind Rose Tables

For the specified wind-speed groups and time of day, the output for Option 5 gives the number of weather observations and percent occurrence of wind by 16 points of the compass. The data are also presented cross-classified by specified ceiling and visibility conditions.

Option 6--Ceiling and Visibility

For the specified ceiling and visibility conditions, the output for Option 6 gives the number of weather observations, by month and by year in each of the ceiling and visibility categories.

Runway Capacity Models

The runway capacity model calculates capacity as the inverse of a weighted average service time of all aircraft being served. The capacity model uses a set of input parameters to determine the minimum time separation (or interval) between operations. The time intervals are computed for different types of aircraft (e.g., Boeing 747 followed by Cessna 150) and for different types of operations (e.g., arrivals and departures), taking into account ATC rules, weather conditions, runway occupancy times, runway configuration, and aircraft operating characteristics. The time intervals are then averaged and inverted to produce the capacity estimates.

Inputs

The inputs required for the runway capacity models include:

1. <u>Ceiling and Visibility</u>. For capacity computation purposes, ceiling and visibility can generally be divided into four sets:

   ● VFR1--VFR conditions that allow simultaneous operations on close parallel runways.

   ● VFR2--VFR conditions that do not allow simultaneous operations on close parallel runways.

   ● IFR1--IFR conditions that allow relief from the two-mile departure-arrival separation rule.

   ● IFR2--IFR conditions just above operating minima.

   Depending on the extent of information required to meet study objectives, analysis of weather conditions and ATC operating procedures may be required.

2. <u>Runway Use</u>. Runway use is defined in terms of the number, location, and orientation of active runways and involves the directions and kinds of operations using each runway. Analysis of wind conditions and runway constraints (e.g., noise, airspace, obstructions) may be required to select appropriate runway uses.

3.   Aircraft Mix. Aircraft mix is defined in terms of four aircraft classes: A, B, C, and D, as shown in the following tabulation:

Aircraft Classi- fication	Types of Aircraft[a]
Class A	Small single-engine aircraft weighing 12,500 lb[b] or less (e.g., PA18, PA23, C180, C207)
Class B	Small twin-engine aircraft weighing 12,500 lb[b] or less and Lear jets (e.g., PA31, BE55, BE80, BE99, C310, C402, LR25)
Class C	Large aircraft weighing more than 12,500 lb[b] and up to 300,000 lb[b] (e.g., CV34; CV58; CV88; CV99; DC4; DC6; DC7; L188; L49; DC8-10, 20 series; DC9; B737; B727; B720; B707-120; BA11; S210)
Class D	Heavy aircraft[c] weighing more than 300,000 lb (e.g., L1011; DC8-30, 40, 50, 60 series; DC10; B707-300 series; B737; VC10; A300; Concorde; IL62)

———————————

a. For aircraft type designators, see FAA Handbook No. 7340.1E with changes.
b. Weights refer to maximum certificated takeoff weight.
c. Heavy aircraft are capable of takeoff weights of 300,000 lb or more whether or not they are operating at this weight during a particular phase of flight. (Reference FAA Handbook 7110.65 with changes.)

The proportion of aircraft in each class during the hour for which capacity is to be calculated should be obtained by examination of tower counts, field surveys, etc. If the mix differs between runways because of runway restrictions etc., the mix on each runway should be given.

4. **Percent Arrivals**. The percent of all aircraft operations that are arrivals. Information can be obtained by examination of tower counts, field surveys, etc.

5. **Percent Touch-and-Go**. The percent of all aircraft operations that are touch-and-go (training) operations. A touch-and-go operation is counted as two aircraft operations (an arrival and a departure). Information can be obtained by examination of tower counts, field surveys, etc.

6. **Exit Configuration**. The location and type of each exit taxiway on runways used for arrival aircraft operations. The Airfield Layout Plan or similar sources can be used to obtain the information.

7. **Runway Occupancy Times**. Arrival, departure, and touch-and-go occupancy times in seconds by aircraft class. Arrival runway occupancy times are required for each exit, together with the percent utilization of each exit by each aircraft class.

8. **Aircraft Separations**. Consistently achievable minimum separations between aircraft. Separation values are needed by each pair of aircraft classes (e.g., Class A followed by Class B).

9. **Common Approach Path Length**. The length of the straight-in approach along the extended runway centerline (for which the controller cannot exert speed control) in nautical miles for each aircraft class.

10. **Approach Speed**. The mean approach speed in knots of each aircraft class over the length of the common approach path.

11. **Clearance Time**. For airports with intersecting runways, mean arrival and departure intersecting runway clearance times in seconds by aircraft class.

Output

The output from the model is the hourly runway capacity of
the runway use under consideration. The capacity computed
represents the maximum number of aircraft operations that
can take place on the runway(s) under the specific
conditions studied.

Appendix B

IMPROVEMENT ITEMS

MIAMI INTERNATIONAL AIRPORT IMPROVEMENT PROGRAM

Near-Term Airport Improvements

Summary

The critical near-term airport improvements required to increase the peak hour capacity of MIA are summarized below:

- Improve the taxiway system of runway 9L/27R.

  Install runway centerline lighting and touch down zone lighting on runway 9L. Install dual 250 foot baseline RVR systems on runway 9L/27R.

- Install runway centerline lighting and dual 250 foot baseline RVR systems on runway 9R/27L.

- Install High Intensity Runway Lights, an Instrument Landing System and an Approach Lighting System on runway 30. Provide paved blast protection shoulders on runway 12/30. Implement operational procedures to make greater use of the intersection take-off position on runway 30 and simultaneous use of runway 12 and 9R.

B-1

- Upgrade Opa Locka and Tamiami General Aviation Reliever Airports, to encourage low performance general aviation aircraft to relocate out of MIA.

- Study the feasibility of installing a VOR-DME on or in close vicinity to MIA.

- Use two mile in-trail staggered parallel approaches at MIA, to improve capacity without the extra tower staff required for full independent parallel approaches.

- Install Vortex Advisory System (VAS) monitors at both ends of all three runways at MIA.

- Provide overflow aircraft parking positions within the terminal area.

- Complete the interior service road totally around the perimeter of the airfield.

- Ask the airlines to taxi, rather than to tow their aircraft between their bases and their gates, and vice versa, during peak traffic periods.

Implementation of the above recommendations will result in the increases in capacity of MIA shown in Table IV-1.

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TABLE IV-1

1985 Hourly Airport Capacity (Assuming 50% Arrivals, 50% Departures)

(1985 Design Hour Demand is Approximately 108 Operations Per Hour)

Weather	East Operations		West Operations	
	No Improvements	With Improvements	No Improvements	With Improvements
Visibility greater than 5 miles; ceiling greater than 1,500 feet	96	106[1]	110	125[1]
Visibility between 3 miles[2] and 5 miles; ceiling between 1,000 feet[2] and 1,500 feet	86	102[2]	86	113[2]
Visibility between 2,400 feet RVR and 3 miles[2]; ceiling between 200 feet and 1,000 feet[2]	86	92[1]	86	92[1]
Visibility between 1,600 feet/1,800 feet RVR and 2,300 feet RVR	36 depart	76 depart or 38 depart + 30 arriv	36 depart	76 depart
Visibility between 1,200 feet RVR and 1,800 feet RVR	0	76 depart or 38 depart + 30 arriv	0	76 depart
Visibility between 600/700 feet RVR and 1,800 feet RVR	0	76 depart	0	76 depart

(1) Including five more air carrier aircraft per hour.

(2) Minima jet to be finalized. Minima shown are used at Chicago O'Hare for similar procedure.

The following sections discuss each of the above items in a format
which identifies:

a. The present operational problems.

b. The operational requirements which will
    solve those problems.

c. The agency/agencies responsible for imple-
    menting those operational requirements. The agency
    responsible for implementing each operational
    requirement is noted using the following codes:

    AL   = Airlines
    DCAD = Dade County Aviation Department
    FAA = Federal Aviation Administration

RUNWAY 9L/27R

The Problems

Runway 9L/27R is the most heavily used runway on the airport, but the
runway's capacity is limited by its poor taxiway system, which should
be improved.

The take-off minima on runway 9L/27R urgently need lowering, to reduce
outbound delays during winter morning fog conditions. A feasibility
study also should be performed to determine if it is possible to
upgrade one runway at MIA to Category II minima.

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The Operational Requirements

a. Provide new runway exit taxiways, dual parallel taxiways and
   an eastern by-pass taxiway to runway 9L/27R. Provide an
   extension of taxiway "L" to a holding apron on the north
   side of runway 9L.
   Agencies responsible: DCAD and FAA

b. Install runway centerline lighting on runway 9L/27R. Install
   touch down zone lighting on runway 9L.
   Agencies responsible: DCAD and FAA

c. Modify the runway 9L Runway Visual Range (RVR) System baseline
   from 500 to 250 feet. A new 250 foot baseline RVR System
   should be installed on runway 27R.
   Agencies responsible: DCAD and FAA

d. Determine the feasibility of upgrading runway 9L to Category II
   landing minima. If it is not technically feasible to upgrade
   runway 9L, then determine which existing or planned runway
   (e.g., the extended runway 9R) that would be possible to
   upgrade to Category II.
   Agency responsible: FAA

   Implementation of operational requirements b, c, d (centerline
   lighting, a second RVR and touch down zone lighting) will result

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in a 25% improvement in landing minima (from 2,400 feet RVR to 1,800 feet RVR) and a 66% improvement in take-off minima (from 1,800 feet RVR to 700 feet/600 feet RVR) on runway 9L.

RUNWAY 9R/27L

Runway 9R has no RVR System. Take off minima on the RVR equipped runway 27L is 1,600 feet RVR. Runway 9R/27L should be equipped with centerline lighting. A new 250 foot baseline RVR should be installed on runway 9R. The existing runway 27L RVR baseline should be reduced to 250 feet. Take off minima on runways 9R and 27L then would be lowered to 700 feet/600 feet.

RUNWAY 12/30

The Problems

Runway 12/30 plays a vital role in the operation of MIA, as the highest peak-hour capacity of the airport is obtained by completely integrating the use of runway 12 with the use of runways 9L and 9R, when on east operations; and completely integrating the use of runway 30 with the use of runways 27L and 27R, when on west operations. (On east operations: land runway 9R, take off runway 12, land and take off runway 9L. On west operations: land runway 30, take off runway 27L, land and take off runway 27R.) At present, however, runway 30 has no instrument approach. It also is not possible to clear B-747 aircraft to take-off on runway 12/30 as the runway is only 150 feet wide, with no blast protection shoulders.

Although the runway 9L Runway Visual Range (RVR) System is
positioned also to serve runway 12, and the runway 27L RVR System
is positioned also to serve runway 30, RVR values cannot be
provided for runway 12/30, as RVR values are only applicable on
runways fitted with High Intensity Runway Edge Lights (HIRL).
During winter morning fog conditions, therefore, only one runway
is available to handle the morning departure peak, when two
runways would more effectively handle the traffic demand and
reduce the resulting take-off delays.

The intersection take-off position on runway 30 should be more
extensively used, in order to achieve higher utilization of this
runway.

The ability for the FAA tower to clear an aircraft to take-off on
runway 12, simultaneously with clearing an aircraft to land on
runway 9R, and vice versa, would greatly increase the capacity of
these runway combinations, which need to be used extensively during
east operations.

The Operational Requirements

a. Install an Instrument Landing System (ILS) and an Approach
   Lighting System (ALS) on runway 30.
   Agencies responsible: DCAD and FAA

b. Construct paved shoulders on runway 12/30 to enable this
   runway to be used for B-747 take-offs.
   Agencies responsible: DCAD and FAA

c. Install a High Intensity Runway Lighting System (HIRL) on
   runway 12/30.
   Agencies responsible: DCAD and FAA

d. Advise the airlines to brief their pilots, and include in
   their flight manuals, the availability of the intersection
   take-off position on runway 30. (8,000 feet available.)
   Agency responsible: AL

e. FAA MIA Tower should initiate discussions with FAA region to
   obtain authority for Miami tower to issue simultaneous
   clearances for landings on runway 9R, with departures on
   runway 12 , and vice versa.
   Agency responsible: FAA

LOW PERFORMANCE GENERAL AVIATION AIRCRAFT

The Problem

During the winter peak traffic months, up to 200 general aviation
aircraft use MIA each day. Over 70% of these aircraft (approximately
150 each day) are single or light twin-engined propeller driven
aircraft, with very low airspeeds. The large numbers of these small

low performance general aviation aircraft using MIA during peak
hours (often over 20 aircraft an hour) cause extensive delays to
the large air carrier aircraft, because of the long ATC separations
required between the small low-performance aircraft and the large
high-performance airline aircraft. (Present separations required
are 6 miles, or 3 minutes between a "heavy" airline aircraft and a
small general aviation aircraft.) At the present time, over 40%
of the airline operations at MIA during peak hours are by "heavy"
or wide-body aircraft. It is forecast that by 1980 over 50% of
the airline operations at MIA during peak hours will be "heavy"
aircraft. Three minutes of delay to a heavy wide-body aircraft
costs that aircraft approximately $150. If several large air
carrier aircraft are delayed for the same three minutes, the delay
costs to the airlines by one small general aviation aircraft could
rapidly exceed $1,000. The Dade County Aviation Department receives
$3 for the general aviation aircraft landing fee. Also, when a small
low performance general aviation aircraft is using the runway, a
large air carrier aircraft cannot be using it and is further delayed.

The Operational.Requirements

The conveniently located General Aviation Reliever Airports at Opa
Locka and Tamiami should be upgraded, in order to make these airports
so attractive to the small low performance general aviation aircraft
now using MIA that they will prefer to use Opa Locka or Tamiami instead
of MIA.

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a. Improvements which should be provided at Opa Locka Airport, and which are shown on the Airport Layout Plan, include:

   (1) Install a full ILS (localizer, glideslope, markers) and Approach Lighting System (ALS) together with an RVR System on runway 9L.

   (2) Upgrade the runway and taxiway system at Opa Locka as shown on the Opa Locka ALP, to enable FAA tower to provide better airport traffic management and improve airfield capacity.

b. Improvements which should be made at Tamiami Airport and which will be shown on the Tamiami ALP now being prepared, include:

   (1) Extend runway 9R, and later runway 9L, to a length of at least 6,500 feet.

   (2) Install an ILS, MALSR, VASI's and RVR on the runway 9R. Also, install VASI's on the present runway 9L.

   (3) Upgrade the taxiway system to provide dual-parallel taxiways to both runways 9L/27R and 9R/27L.

VOR-DME/PROFILE DESCENT PROCEDURES

The Problem

A VOR-DME on, or in the close vicinity of, Miami International
Airport will enhance the ability of air carrier aircraft to perform
profile-descent procedures. These procedures will provide a reduction
in pilot-controller workload, a reduction in aircraft noise impact on
the community, and permit significant savings of fuel. Departing
aircraft also will be provided with multiple departure tracks, enabling
higher departure rates to be maintained, thus reducing departure
delays. A considerable number of other air traffic management benefits
also would occur within the complete Miami terminal area. Both ATA
and FAA tower, therefore, strongly support a VOR-DME on, or in the close
vicinity of, Miami International Airport.

The Operational Requirements

a. Study the feasibility of installing a VOR-DME on, or in close vicinity
to, Miami International Airport. (It is recognized that technical
implementation of this operational requirement will be difficult, due
to the limited availability of suitable land areas on MIA, the cost
of land ff the airport, and the technical limitations of the existing
normal range of VOR-DME equipment. The operational requirement,
however, is stated in the hope that FAA technical staff could work
closely with DCAD technical staff to implement this urgent
operational requirement.)

Agencies responsible: DCAD and FAA

TWO-MILE STAGGERED-PARALLEL APPROACHES

The Problem

Full parallel-runway approaches at MIA result in a very high airfield landing rate and low inbound delays, but require a large FAA tower staff to perform. A fairly high landing rate, however, also can be maintained if two-mile staggered-parallel approaches can be maintained. An arrival on final approach to 9L, for example, could be a close as two miles behind an arrival to 9R; there would then be at least four miles between successive arrivals to 9R. The two-mile staggered-parallel approaches can be performed with a smaller FAA tower staff and thus are highly suited to occasional short periods of high inbound demand.

The Operational Requirement

FAA Miami tower should clear aircraft for two-mile staggered-parallel approaches on runways 9L/27R and 9R/27L at MIA. FAA Miami tower should initiate discussions with FAA regional office to obtain the required approvals.

Agency responsible: FAA

WAKE VORTEX

The Problem

The very limited weather conditions under which wake vortices behind "heavy" aircraft persist are well-known, but in order to positively protect all aircraft all the time, the large wake-vortex separation minima are applied under all weather conditions. At the present time, over 40% of airline aircraft operations at MIA during peak hours are

by "heavy" aircraft. It is forecast that by 1980 over 50% of
MIA's peak hour aircraft operations will be by "heavy" aircraft.
The delays presently caused by these large separation standards
will therefore become even worse by 1980.

The Operational Requirement

Vortex Advisory System (VAS) monitors should be installed at
both ends of all three runways at MIA, so that reduced ATC separations
and higher airport capacity, resulting in a decrease in aircraft delays,
can be achieved at MIA whenever weather conditions permit.

Agencies responsible: DCAD and FAA

OVERFLOW PARKING POSITIONS

The Problem

During peak traffic periods some airlines have more aircraft arriving
than there are free gates at which to park them. The overflowing aircraft
then have to be held on an adjacent taxiway, until a gate is available.
Concourse "G", in particular, is a continuing problem, and an Air
Canada B-747, or a United, Continental, or Northwest DC-10 will often
have to hold on the adjacent taxiway for up to an hour while waiting
for a free gate. The taxiway then is no longer available for the
normal passage of arriving and departing aircraft. In some cases this
taxiway is the only reasonable route between large area of the airport.
Lack of it quickly causes delays and congestion for all aircraft on
the airport, as more complex, circuitous and time-consuming alternative
routes have to be set up by the FAA tower ground controllers.

The Operational Requirements

The overall utilization of Concourse "G" should be studied, as it is obviously continually overloaded during peak hours during the winter season. Overflow parking positions also must be found for large, wide-body airline aircraft which do not have a parking gate. These overflow parking positions must be within the present terminal area, and not involve the crossing, or recrossing, of the airfield runway system.

Agency responsible: DCAD

VEHICULAR TRAFFIC ON AIRFIELD OPERATIONS AREA

The Problem

The FAA tower has complained and DCAD operations has acknowledged, that there are too many radio-equipped vehicles authorized to drive on the airfield operations area. The constant flow of these vehicles, particularly across runway 9L/27R and along the Route 1 taxiway, causes severe FAA tower ground controller radio-frequency congestion, heavy controller workload, delays to taxiing aircraft, and reduced aircraft safety, as these vehicles occasionally inadvertently cross active runways without clearance. The new FAA procedures requiring each runway crossing to be cleared individually on each occasion between the ground controller and the local controller, also increases the workload on the local controller and reduces his efficiency in controlling aircraft in an expeditious manner.

The Operational Requirement

The interior service road should be completed totally around the perimeter of the airfield operations area. When this interior service road is completed, all vehicles should be ordered to use the roadway, rather than the airfield. All radio certificates then should be withdrawn and replaced only on a case-by-case basis, after the most rigorous examination.

Agency responsible: DCAD

TOWING AIRCRAFT

The Problem

Due to the location of Miami in the airline route network, a large traffic peak occurs between approximately 1200 hours and 1500 hours local time.

Severe taxiway congestion occurs during this period if a stream of inbound or outbound aircraft are held up behind a towed aircraft, with the slow speeds of even a modern tug pulling a large aircraft. A considerable reduction in taxiway congestion and delays and a significant increase in airport capacity would be possible if aircraft positioning between the maintenance areas and the gates, or between the gates and the maintenance areas, could be taxied, rather than towed, during the peak traffic period.

<u>The Operational Requirement</u>

The airlines should be asked to taxi their aircraft between their maintenance areas and their gates, and vice-versa, during the peak hours of airport operations. (Presently 1200 to 1500 hours, local time.)

Agencies responsible: AL and DCAD

Appendix C

INPUT DATA FORMS

AIRFIELD SIMULATION MODEL

LINK DATA

Link Number (cc 1-4)	Gate Size (cc 9-16)	Link Length (cc 17-24)	Speed Code (cc 33-40)	2-Way Path No. (cc 49-56)	Link Number (cc 1-4)	Gate Size (cc 9-16)	Link Length (cc 17-24)	Speed Code		

Figure C-1

LINK DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

C-1

GATE DATA

Gate #	Airline	Aircraft Type	Push Back ?	Push Back Time	Remarks

Figure C-2

GATE DATA
Miami International Airport
C-2   Delay Improvement Study
October 1978

AIRFIELD SIMULATION MODEL
SEPARATION DATA

| Operation Code (cc 8) | Lead Aircraft | | | | Trail Aircraft | | | | Mean Separation (cc 65-72) | Std Dev Separation (cc 73-80) |
	Class Number (cc 15-16)	Runway Number (cc 24)	Fix Number (cc 31-32)	Operation Code (cc 40)	Class Number (cc 48)	Runway Number (cc 56)	Fix Number (cc 61-64)		

Figure C-3

SEPARATION DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

AIRFIELD SIMULATION MODEL

ROUTE DATA

LINK NUMBERS

Figure C-4

ROUTE DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

AIRCRAFT GATE SERVICE TIMES
(consistently achievable when under pressure)

Airline _____

Aircraft Type[a]	Operation Type[b]	Service Time[c] (minutes)		
		Minimum	Normal	Maximum

a. e.g. B727-200
b. e.g. Through, turnaround.
c. e.g. 35 minimum, 40 normal, 50 maximum.

Figure C-5

AIRCRAFT GATE SERVICE TIMES
Miami International Airport
C-5 Delay Improvement Study
October 1978

AIRFIELD SIMULATION MODEL
RUNWAY/FIX TRAVEL DATA

Fix Number (cc 6-8)	Runway Number (cc 16)	Class Number (cc 24)	Distance (cc 25-32)	Average Speed (cc 33-40)

Figure C-6

AIRSPACE TRAVEL TIME DATA FORM
Miami International Airport
Delay Improvement Study
October 1978

ARRIVAL AIRCRAFT LATENESS DISTRIBUTION
(Average deviation from schedule, excluding delays
due to destination airport)

Airline _____

Percent of flights late or early (%)	Amount of time Late or early
	More than 30 minutes early
	15 to 30 minutes early
	Less than 15 minutes early
	On time
	Less than 5 minutes late
	5 to 10 minutes late
	10 to 15 minutes late
	15 to 30 minutes late
	30 to 45 minutes late
	45 to 60 minutes late
	More than 60 minutes late

Total   100%

Figure C-7

ARRIVAL AIRCRAFT LATENESS DISTRIBUTION
Miami International Airport
Delay Improvement Study
October 1978

C-7

AIRFIELD SIMULATION MODEL

DEMAND DATA

Airline Code (cc 1-4)	Flight Number (cc 5-8)	Gate (cc 9-12)	Holding Area (cc 13-16)	Flight Type (cc 24)	Aircraft Class (cc 32)	Scheduled Arrival Time (cc 36-40)	Scheduled Departure Time (cc 44-48)	Arrival		Departure	
								Fix (cc 56)	Runway (cc 64)	Fix (cc 72)	Runway (cc 80)

Figure C-8

C-8 DEMAND DATA FORM
Miami International Airport
Delay Improvement Study
October 1978